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MARTIN MARIETTA

ORNL WAG 6
Site Characterization Summary

Volume I. Main Report

Bechtel National, Inc.

ChemRisk Document No. 1228

MARTIN MARIETTA ENERGY SYSTEMS, INC.
UNITED STATES
DEPARTMENT OF ENERGY

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Environmental Restoration Division
ORNL Environmental Restoration Program

ORNL WAG 6
Site Characterization Summary

Volume I. Main Report

March 1990

Prepared by
Bechtel National, Inc.
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CONTENTS

VOLUME I: MAIN REPORT

	<u>Page</u>
Figures	vi
Tables	ix
Acronyms	xii
Abbreviations	xvi
Executive Summary	1
 1.0 Introduction	 1-1
1.1 RFI Scope and Objective	1-6
1.2 Project Phasing	1-6
 2.0 Site Description and Background	 2-1
2.1 Site Description	2-1
2.2 Site History	2-8
2.2.1 SWSA 6 (SWMU 6.1)	2-8
2.2.2 The Explosives Detonation Trench	2-20
2.2.3 The Emergency Waste Basin	2-22
2.3 Previous Investigations	2-22
2.3.1 General Programs of Site Investigation	2-22
2.3.2 Source Characterization	2-27
2.3.3 Geologic and Soils Investigations	2-31
2.3.4 Surface Water and Sediment Investigations	2-37
2.3.5 Groundwater Investigations	2-39
2.3.6 General Reviews	2-44
 3.0 Site Investigation	 3-1
3.1 Data Quality Review (Technical Memorandum 06-01)	3-1
3.2 Existing Well Investigation (Technical Memorandum 06-02)	3-3
3.3 Soil Gas Investigation (Technical Memorandum 06-03)	3-3
3.4 Surface Radiological Investigation (Technical Memorandum 06-04)	3-4
3.5 Surface Water Investigation (Technical Memorandum 06-05)	3-5
3.6 Electromagnetic (EM) Survey (Technical Memorandum 06-06)	3-6
3.7 Validation of Existing ORNL Groundwater Data (Technical Memorandum 06-07)	3-6
3.8 Monitoring Well Installation and Development (Technical Memorandum 06-08)	3-7
3.9 Groundwater Investigation (Technical Memorandum 06-09)	3-7
3.10 Biohazard Investigation (Technical Memorandum 06-10)	3-8
3.11 Waste Management (Technical Memorandum 06-11)	3-9
3.12 Soil Investigation (Technical Memorandum 06-12)	3-9

CONTENTS (Continued)

	<u>Page</u>
VOLUME I: MAIN REPORT (Continued)	
4.0 Physical Characteristics	4-1
4.1 Topography	4-1
4.2 Surface Features	4-3
4.3 Geology	4-3
4.4 Surface Water Hydrology and Sediments	4-16
4.5 Soils	4-21
4.6 Hydrogeology/Groundwater	4-25
5.0 Nature and Extent of Contamination	5-1
5.1 Radiological Contamination	5-2
5.1.1 Source Information	5-10
5.1.2 Tritium	5-12
5.1.3 Cobalt-60	5-14
5.1.4 Strontium-90	5-17
5.1.5 Cesium-137	5-20
5.1.6 Transuranics	5-20
5.1.7 Potassium-40	5-23
5.1.8 Uranium, Thorium, and Actinium Series Radionuclides	5-24
5.2 Chemical Contamination	5-24
5.2.1 Source Areas	5-36
5.2.2 Organic Chemical Contamination	5-38
5.2.3 Polychlorinated Biphenyls (PCBs)	5-69
5.2.4 Inorganic Chemical Contamination	5-70
5.3 Biological Contamination	5-72
5.3.1 Background	5-72
5.3.2 Phase I Investigation	5-73
5.3.3 Phase II	5-77
5.3.4 Conclusions	5-82
5.4 Summary of Nature and Extent of Contamination	5-82
5.4.1 Radiological Contamination	5-83
5.4.2 Chemical Contamination	5-85
5.4.3 Biological Contamination	5-88
6.0 Contaminant Fate and Transport	6-1
6.1 Introduction	6-1
6.2 Approach to Screening Analysis in WAG 6	6-3
6.3 Application of the Screening Approach	6-4
6.3.1 Source Definition	6-4
6.3.2 Pathways Modeled	6-10
6.3.3 Exposure Point Locations	6-10
6.3.4 Models and Assumptions	6-10
6.4 Results and Discussion	6-15
6.4.1 Area A	6-15
6.4.2 Area B	6-15
6.5 Conclusions	6-21

CONTENTS (Continued)

Page

VOLUMES II AND III: APPENDIX A
TECHNICAL MEMORANDUMS

VOLUME IV: APPENDIX B
NATURE AND EXTENT OF CONTAMINATION

FIGURES

<u>Figure</u>	<u>Title</u>	<u>Page</u>
2-1	Map of the Oak Ridge, Tennessee Area Showing Location of the Oak Ridge Reservation	2-2
2-2	Map of the DOE Oak Ridge Reservation	2-3
2-3	Location of WAG 6 to Other Adjacent ORNL WAGs	2-4
2-4	Topographic Map of ORNL and the Surrounding Area	2-5
2-5	Location of WAG 6 Solid Waste Management Units	2-6
2-6	WAG 6 Solvent Auger Hole and Biological Trench Areas	2-10
2-7	Plan View of SWSA 6 Showing Locations of the Silo Areas in Relation to Existing Trench and Auger Hole Areas	2-14
2-8	Location of WAG 6 ICM Caps	2-17
4-1	Topography and Drainage Patterns at WAG 6 and Adjacent Areas	4-2
4-2	WAG 6 Surface Features	4-4
4-3	Generalized Geologic Map of the ORNL Study Area	4-6
4-4	Generalized Geologic Cross Section A-A'	4-7
4-5	Geologic Map of WAG 6	4-12
4-6	Representative Stratigraphic Columns--WAG 6	4-13
4-7	WAG 6 Surface Water Features	4-17
4-8	White Oak Creek Watershed	4-18
4-9	WAG 6 Stream Sediments Sampling Locations	4-22
4-10	Subsurface Zones and Directions of Groundwater Flow	4-32
4-11	Conceptual Hydrologic Settings for Trenches in WAG 6	4-33

FIGURES (Continued)

<u>Figure</u>	<u>Title</u>	<u>Page</u>
4-12	Conceptual Groundwater Flow and Contaminant Transport in WAG 6	4-34
4-13	Groundwater Level Contours--WAG 6	4-36
4-14	Locations of Known Groundwater Wells in WAG 6	4-40
5-1	WAG 6 Waste Disposal Areas	5-11
5-2	Distribution of Tritium	5-13
5-3	Cobalt-60 in Trench Leachate, Groundwater, and Surface Water	5-15
5-4	Distribution of Cobalt-60 in Soils and Sediments	5-16
5-5	Distribution of Strontium in Trench Leachate, Groundwater, and Surface Water	5-18
5-6	Distribution of Strontium in Sediments and Soils	5-19
5-7	Distribution of CS-137 in Trench Leachate, Groundwater and Surface Water	5-21
5-8	Distribution of CS-137 in Soils and Sediments	5-22
5-9	WAG 6 Solvent Auger Hole and Biological Trench Areas	5-37
5-10	Distribution of Chloroform	5-43
5-11	Distribution of Vinyl Chloride	5-44
5-12	Distribution of 1,2-Dichloroethene	5-45
5-13	Distribution of Trichloroethene	5-46
5-14	Distribution of Tetrachloroethene	5-47
5-15	Distribution of 1,1-Dichloroethane	5-48
5-16	Distribution of 1,2-Dichloroethane	5-49
5-17	Distribution of 1,2-Trichloroethane	5-50
5-18	Distribution of 1,1,2,2-Tetrachloroethane	5-51
5-19	Distribution of Benzene	5-57
5-20	Distribution of Ethyl Benzene	5-58

FIGURES (Continued)

<u>Figure</u>	<u>Title</u>	<u>Page</u>
5-21	Distribution of Toluene	5-59
5-22	Distribution of Xylene	5-60
5-23	Tentatively Identified Organic Compounds in Soils	5-64
5-24	Distribution of Bis (2-ethylhexyl) Phthalate	5-66
5-25	Soil Microbiological Sample Locations Phase I	5-74
5-26	Phase 1 and 2 Map of Documented Piezometers and Water Quality Wells	5-80
5-27	Radionuclides Exceeding Human Health Criteria in Water	5-84
5-28	Compounds Exceeding Human Health Criteria in Groundwater and Surface Water	5-87
6-1	WAG 6 Auger Hole Area	6-2
6-2	Co-60 Concentration in Well #842	6-20
7-1	WAG 6 Institutional Time Periods	7-7
7-2	Boundaries Within the Oak Ridge Reservation During the Controlled Periods	7-9
7-3	Preliminary Human Exposure Pathways	7-12
8-1	Alternatives Development and Analysis	8-3
8-2	Potential Remedial Actions by Pathway	8-8
8-3	Remedial Technology Description	8-10

TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
2-1	Waste Items Detonated at the Explosives Detonation Trench	2-21
3-1	RFI Technical Memorandums	3-2
4-1	Generalized Stratigraphy of the Conasauga Group	4-9
4-2	Monthly Climatic Summary for the NOAA Station in Oak Ridge (1965-1985)	4-20
4-3	Distribution Coefficients of Selected Radionuclides For Soils From Three Depth Profiles of the Engineered Test Facility Site	4-24
4-4	Relationship of Hydraulic Conductivity to Type of Aquifer Material	4-27
4-5	Relationship of Hydraulic Conductivity to Geologic Formation or Group	4-28
4-6	Statistical Characteristics of Hydraulic Conductivity Values for Bedrock Lithology of the Water-Producing Intervals	4-29
4-7	Statistical Characteristics of Hydraulic Conductivity Values for Selected Classes of Well Depth	4-30
5-1	Comparison of RFI Groundwater Data for Radionuclides with Health Based Criteria	5-3
5-2	Comparison of RFI Surface Water Data for Radionuclides with Health Based Criteria	5-4
5-3	Comparison of RFI Subsurface Soil Data for Radionuclides with Health Based Criteria	5-5
5-4	Comparison of RFI Surface Soil Data for Radionuclides with Health Based Criteria	5-6
5-5	Comparison of Trench Leachate and Groundwater Radionuclide Data from Previous Investigations with Human Health Criteria	5-7
5-6	Comparison of Sediment and Soil Radionuclide Data from Previous Investigations with Human Health Criteria	5-8
5-7	Comparison of RFI Groundwater Data for Chemicals with Health Based Criteria	5-25

TABLES (Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
5-8	Comparison of RFI Surface Water Data for Chemicals with Health Based Criteria	5-27
5-9	Comparison of RFI Subsurface Soil Chemicals with Health Based Criteria	5-29
5-10	Comparison of RFI Surface Soil Data for Chemicals with Environmental Criteria	5-31
5-11	Comparison of Trench Leachate and Groundwater Chemical Data from Previous Investigations with Health Based Criteria	5-32
5-12	Comparison of Soil Chemical Data from Previous Investigations with Health Criteria	5-34
5-13	TCL Organic Compounds Detected at WAG 6	5-39
5-14	Comparison of Inorganic Constituents in Soil with Typical Background Levels	5-71
5-15	SWSA 6 Soil Microbiological Data, Phase 1	5-75
5-16	SWSA 6 Groundwater Microbiological Results, Phase 1	5-76
5-17	SWSA 6 Locations Sampled, Phase 2	5-78
5-18	Bacteriological Profile of Samples from SWSA 6, Phase 2	5-81
6-1	Radionuclide Inventory For Auger Holes in Area A ¹	6-6
6-2	Radionuclide Inventory For Auger Holes in Area B ¹	6-8
6-3	Input Parameters for Area A Simulation	6-16
6-4	Input Parameters for Area B Simulation	6-18
6-5	Results of the Model Simulations, 130 Years After 1980	6-22
7-1	List of Radionuclides of Potential Concern In Environmental Media at WAG 6	7-3
7-2	List of Chemicals of Potential Concern In Environmental Media at WAG 6	7-4

TABLES (Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
7-3	Water ARARs or TBCs for Chemicals of Potential Concern at WAG 6	7-18
7-4	Soil TBCs for Chemicals of Potential Concern at WAG 6	7-20
7-5	ARARs or TBCs for Radionuclides at WAG 6	7-24
7-6	Water ARARs or TBCs for Chemicals of Potential Concern at WAG 6	7-25
8-1	General Response Actions, Typical Associated Remedial Technologies, and Evaluation	8-5
8-2	Screening of Technologies	8-13

ACRONYMS

AA	Alternatives Assessment
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
ARAR	Applicable or Relevant and Appropriate Requirement
ASME	American Society of Mechanical Engineers
BNI	Bechtel National, Inc.
BOD	Biochemical Oxygen Demand
BTX	Benzene, Toluene, and Xylene
CCE	Calcium Carbonate Equivalent
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Restoration, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
COD	Chemical Oxygen Demand
CSL	Close-Support Laboratory
DC	Direct Current
DM	Deep Monitoring
DO	Dissolved Oxygen
DOE	U.S. Department of Energy
DQO	Data Quality Objectives
ECAO	Environmental Criteria and Assessment Office (EPA)
EDT	Explosives Detonation Trench
EIS	Environmental Impact Statement
EM	Electromagnetic
EP	Extraction Procedure
EPA	U.S. Environmental Protection Agency
ES&H	Environmental, Safety and Health
ESD	Environmental Sciences Division
ETF	Engineered Test Facility
EWB	Emergency Waste Basin
FSP	Field Sampling Plan

ACRONYMS (Continued)

FSS	Field Services and Support
GC	Gas Chromatograph
GCD	Greater Confinement Disposal
GPR	Ground Penetrating Radar
HAA	Halogenated Alkenes and Alkanes
HDPE	High-Density Polyethylene
HEA	Health Effects Assessment
HF	Hydrofracture Facility
HFIR	High Flux Isotope Reactor
HHMS	Hydraulic Head Monitoring Station
HSWA	Hazardous Solid Waste Act
ICM	Interim Corrective Measure
ICP	Inductively Coupled Plasma
IRIS	Integrated Risk Information System
IT	International Technology Corporation
IWMF	Interim Waste Management Facility
LLW	Low-Level Waste
MCL	Maximum Contaminant Level
NHF	New Hydrofracture Facility
NRC	U.S. Nuclear Regulatory Commission
OHF	Old Hydrofracture Facility
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Administration
P&A	Plugging and Abandonment
PAH	Polyaromatic Hydrocarbon
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
PHRED	Public Health Risk Evaluation Database

ACRONYMS (Continued)

PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAA	Quality Assurance Assessment
QAMS	Quality Assurance Manual Section
QC	Quality Control
RAP	Remedial Action Program
RAS	Routine Analytical Services
RC	Rock Core
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RII	Remedial Investigation Implementation
RM	Rome
RT	Rutledge
SARA	Superfund Act Reauthorization Amendments
SAS	Special Analytical Services
SOW	Statement of Work
SP	Self-Potential
SPT	Standard Penetration Test
SVOC	Semivolatile Organic Compound
SDWA	Safe Drinking Water Act
SWIMS	Solid Waste Information Management System
SWMU	Solid Waste Management Unit
SWSA	Solid Waste Storage Area
TARA	Test Area for Remedial Activities
TBC	To Be Considered
TCE	Trichloroethene
TCL	Target Compound List
TD	Total Depth
TDHE	Tennessee Department of Health and Environment
TDS	Total Dissolved Solids

ACRONYMS (Continued)

TF	Tear Fault (Well)
TIC	Tentatively Identified Compound
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TOX	Total Organic Halides
TRC	Technical Review Committee
TRU	Transuranic
VES	Vertical Electrical Resistivity Soundings
VOC	Volatile Organic Compound
WAG	Waste Area Grouping
WOC	White Oak Creek
WQC	Water Quality Criteria

ABBREVIATIONS

$\mu\text{g/mL}$	micrograms per milliliter
$\mu\text{mhos/cm}$	micromhos per centimeter
C	Centigrade
Ci	Curies
Ci/L	Curies per liter
cm	centimeter(s)
cm/sec	centimeters per second
ft	foot/feet
ft/mi	feet per mile
ft^2	square feet
ft^3	cubic feet
ft^3/yr	cubic feet per year
gal	gallon(s)
gal/day	gallons per day
gal/ft	gallons per foot
h	hour(s)
Hz	Hertz
in.	inch(es)
km	kilometer(s)
km^2	square kilometers
L	liter(s)
L/sec	liters per second
lb	pound(s)
m	meter(s)
m/d	meters per day
md	millidarcy
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mi	mile
mi^2	square miles
mL	milliliter
mm	millimeter(s)
mR/h	microroentgen per hour
mrem	millirem

ABBREVIATIONS (Continued)

mrem/yr	millirem per year
MSL	Mean Sea Level
pCi/g	picocuries per gram
pCi/L	picocuries per liter
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
yr	year(s)

EXECUTIVE SUMMARY

PURPOSE

This Site Characterization Report provides a summary of historically acquired environmental data and summarizes the initial activities of the Phase 1, Activity 1 work conducted at Waste Area Grouping (WAG) 6 at the Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. This investigation is a portion of a program referred to as the ORNL Remedial Investigation/Feasibility Study (RI/FS), which includes investigation, assessment, and evaluation of corrective measures for environmental releases.

SITE SUMMARY

WAG 6 is located in Roane County, Tennessee, approximately 10 miles southwest of the City of Oak Ridge. WAG 6 is part of ORNL and is located approximately 2 miles southwest of the ORNL Main Plant Area.

WAG 6 is in Melton Valley, bordered on the northwest by Haw Ridge and on the southeast by Copper Ridge. The topography consists of gently to moderately sloping land which drains to a tributary of White Oak Creek (WOC) on the east and to White Oak Lake (WOL) on the south. It is underlain by the Maryville Limestone and Nolichucky Shale, which dip to the southeast.

WAG 6 contains three Solid Waste Management Units (SWMU's):

- o Solid Waste Storage Area (SWSA) 6--SWMU 6.1
- o The Emergency Waste Basin (EWB)--SWMU 6.2
- o The Explosives Detonation Trench (EDT)--SWMU 6.3

SWSA 6 is the largest of the three SWMUs, comprising about 68 acres, 15 of which have to date been used for waste disposal.

Starting in 1969, SWSA 6 received low-level radioactive waste (LLW), chemical, and biological wastes. Since 1986, only LLW has been disposed on the site. Prior to 1986, wastes were disposed in over 510 unlined trenches and 490 auger holes. Since 1986, wastes have been and continue to be disposed in greater confinement disposal (GCD) silos, consisting of cylindrical, vertical, below grade concrete silos with top and bottom caps, and in tumuli (see below).

ORNL waste disposal records indicate that 7 trenches and 19 auger holes contain approximately 90 percent of the total activity buried at the site.

The EWB, physically located outside the boundary of the WAG, was constructed as a LLW or process waste holding basin, but has reportedly never been used for its intended purpose.

The EDT, located in the eastern portion of the WAG, was used to detonate shock sensitive chemicals and explosives. The EDT is now backfilled and covered.

In addition to routine land disposal operations, SWSA 6 has been and continues to be the site of numerous technology demonstrations and interim corrective actions:

- o The Tumulus Disposal Demonstration Project is being conducted to evaluate the effectiveness of tumuli for above-ground disposal of LLW. This facility consists of concrete vaults or casks placed on a concrete pad and overlain by a cap.
- o In 1983, a French drain was installed to prevent lateral movement of groundwater into one grouping of trenches in SWSA 6.
- o A high density polyethylene cap has been placed over all trenches and auger holes identified as having received RCRA regulated wastes between the advent of RCRA coverage (November 1980) and the cessation of hazardous waste burial in 1986.

- o The Engineered Test Facility (ETF) was characterized to develop a hydrologic model of SWSA 6 based on geology, soils, and hydrology.
- o Field studies of dynamic trench compaction and trench grouting have been conducted at SWSA 6. Several types of grout have been evaluated in the various studies.

REGULATORY SETTING

To provide a comprehensive and cohesive approach to addressing the cleanup of areas or facilities where past or present activities have resulted in contamination of facilities or the environment, ORNL developed the Remedial Action Program (RAP). The RAP provides comprehensive management of all radioactivity and chemically contaminated ORNL sites until final closure of the sites.

The RAP was initiated under the auspices of applicable DOE Orders. In 1986, however, a RCRA permit application by ORNL initiated an EPA plan to enforce regulatory requirements for ORNL remedial response activities through RCRA Section 3004(u).

A RCRA Facilities Assessment (RFA)(ORNL, 1987) for ORNL was submitted to EPA in 1987, identifying approximately 250 known active or inactive SWMUs or contaminated facilities, or as potential sources of continuing contaminant release to the environment.

Because of the large number of sites and the interaction among many of them, ORNL proposed to EPA that the SWMUs be combined into WAGs that are geographically contiguous or within defined hydrologic units. The WAG concept was developed to group the remedial action sites into manageable units that could be handled separately. WAG 6 is one of the 20 WAGs so designated.

For each WAG, a separate RFI (or Remedial Investigation) will be conducted to characterize the nature and extent of contamination,

associated risk and potential remedial alternatives. The RFIs will be followed by Corrective Measures Studies (CMS) to determine the need for, and extent of, remedial measures. Through Corrective Measures Implementation DOE will ultimately design, construct, operate, and monitor performance of the remedies selected for each WAG.

In 1988, a Closure Plan for SWSA 6 (BNI, 1988) was submitted to EPA and TDHE. The approved plan included installation of the polyethylene cap over the RCRA regulated areas within SWSA 6, conduct of a multi-phased RFI, completion of a CMS, and, ultimately, construction of facilities for closure and corrective action at the site.

In 1989, DOE and EPA negotiated a draft Federal Facilities Agreement (FFA), documenting the overall plan and schedule for remediation of all DOE facilities on the Oak Ridge Reservation. The earlier agreements regarding SWSA 6 were incorporated into the new agreement, which should be finalized in 1990.

CONTEXT OF THE SITE CHARACTERIZATION REPORT

Over the past decade, a large number of characterization studies, research projects, and technology demonstrations have been conducted at WAG 6. The historical projects provided a good understanding of the physical characteristics of the site, an approximation of the inventory of materials buried at the site, and a clear indication of contamination of soils, sediments, surface water and groundwater within the WAG.

The majority of historical investigations at the site were limited in scope to specific research needs and, as such, were not designed to provide all the information required for an RFI. The studies largely dealt with specific media, in specific locations, and specific contaminants. Prior to the conduct of the Phase 1, Activity 1 RFI, no soil, sediment, surface water,

or groundwater samples had been analyzed for the full suite of chemicals and radionuclides potentially present within the WAG.

The scope of this first phase of the RFI was crafted to determine what contaminants are present at WAG 6 and to determine pathways of contaminant migration away from known sources. Several phases of investigation will be necessary to define the areal and vertical extent to which contaminants have migrated. Based on historical records of materials disposed at SWSA 6 and on historical trench leachate sampling performed by others, it has been assumed that some form of source control/containment will be implemented. RFI investigative efforts, therefore, deal largely with determination of the required areal and vertical extent of necessary remedial actions.

This document has been prepared to fulfill the requirement in the FFA for submission of a preliminary site characterization report. It is critical to note that the Phase 1, Activity 1 investigations at WAG 6 are not yet complete. Both the RI/FS contractor and Energy System's staff are in the midst of validating data which have been taken but are not yet available for use and of planning additional site characterization efforts.

SCOPE OF PHASE 1, ACTIVITY 1 RFI

The following work was conducted during the Phase 1, Activity 1 RFI and is documented herein:

- o All available historical studies were reviewed. As appropriate, relevant data from such studies were extracted and are included in this document to provide a comprehensive assessment of all data regarding contamination of the site and of physical characteristics impacting contaminant migration or remedy selection.
- o A radiation walkover survey was conducted over all accessible areas within SWSA 6.

- o An electromagnetic (EM) survey was conducted around the disposal areas within SWSA 6.
- o Soil gas samples were obtained to help assess the lateral near surface migration of volatile organic compounds.
- o Environmental samples were obtained from the following media within WAG 6:

<u>Media</u>	<u>Number of Sampling Stations Installed/Used</u>	<u>Number of Locations Sampled</u>	<u>Approximate Number of Samples Analyzed</u>
Soils - Borings	53	37	58
- Surface	4	4	4
Water - Wells*	39	39	119
- Surface	16	15	32

* Includes ORNL WAG 6 regulatory compliance monitoring wells.

In general, all samples submitted to the laboratory were analyzed for the full suite of Target Compound List (TCL) compounds and for radionuclides.

- o All analytical data generated during the RFI were reviewed to determine if the intended data quality objectives (DQOs) were met. The data review procedures were based on EPA protocols for data validation.
- o Data were obtained from ORNL's ongoing RCRA groundwater monitoring program. The analytical methods and QC procedures applied by ORNL were reviewed and found to be consistent with the requirements established for this RFI, and the data were incorporated in this report.
- o Historical and RFI-generated data were merged to provide a comprehensive assessment of the physical characteristics of WAG 6 and of the nature and extent of contamination.
- o ARARs and TBCs were assessed for WAG 6 and for the contaminants found to be present.
- o Preliminary objectives for site closure and corrective action were identified.
- o Selected components for the Baseline Risk Assessment are presented.
- o A preliminary assessment of remediation technologies was conducted to determine which may be appropriate for WAG 6.

- o Based on all the above, data gaps were identified where insufficient information is available to complete a risk assessment for the site or to evaluate remedial alternatives. The data gaps so identified comprise the scope of the next phase of the RFI field investigation.

SUMMARY OF MAJOR FINDINGS

Ongoing and planned site characterization efforts will lead to an enhanced understanding of the nature and extent of contamination at WAG 6. This document summarizes all site investigation efforts from which validated data were available.

The WAG 6 Fate and Transport Analysis and the Baseline Human Health Evaluation are still under development. Data necessary to complete these elements were either unavailable in time to incorporate in this document or are planned for upcoming characterization efforts.

Groundwater and Surfacewater

A number of man-made radionuclides, natural radionuclides, organic chemicals, and inorganic chemicals have been found in surface water and groundwater exiting WAG 6. RFI groundwater data are summarized in Tables 5-1 (radionuclides) and 5-7 (chemical). RFI surface water data are summarized in Tables 5-2 (radionuclides) and 5-8 (chemicals). Groundwater data from previous investigations are summarized in Tables 5-5 (radionuclides) and 5-11 (chemical). The concentrations of at least two man-made radionuclides and fifteen organic chemicals were found at levels exceeding human health criteria. The significance of the natural radionuclides and inorganic chemicals found cannot be determined until the results of background sampling are made available.

Subsurface Soils

Contamination of subsurface soils outside the boundary of trench disposal areas does not appear to be at levels of environmental concern. (Subject to evaluation with respect to background concentrations, and completion of the human health evaluation). RFI subsurface soil data are summarized in Tables 5-3 (radionuclides) and 5-9 (chemicals). Subsurface soil samples from previous investigations are summarized in Tables 5-6 (radionuclides) and 5-12 (chemical).

Surface Soils and Sediments

Man-made radionuclides, inorganic chemicals, and organic chemicals were detected in subsurface soils and sediments in surface drainageways leading from WAG 6. RFI surface soil data are summarized in Tables 5-4 (radionuclides) and 5-10 (chemicals). Sediment and surface soil data from previous investigations for radionuclides are summarized in Table 5-6. Surface soil data from previous investigations for chemicals are presented in Table 5-12. The significance of the detected levels will be determined after background concentrations are determined and the human health evaluation is completed.

Biological Hazard

A limited microbiological hazard investigation was performed at WAG 6 to identify potential health and safety concerns. Results of this investigation identified no definitively pathogenic organisms. The most significant finding was the discovery of a previously unidentified pasteurella-like bacteria in groundwater samples. Microbiological data are summarized in Tables 5-15, 5-16 and 5-18. In laboratory tests the bacteria did not appear to be highly virulent; however, live bacteria were recovered from the tissue of infected mice. This issue is undergoing additional study.

Summary

Subsurface soil contamination above levels of environmental concern at WAG 6 appears to be largely confined to areas within the boundaries of trench disposal areas.

Groundwater in the saturated zone appears to be the principal pathway for transport of contaminants from the site. Sediment transport appears to be a minor pathway based on historical data.

Virtually all trench areas contribute to contamination of groundwater at SWSA 6. Phase 1, Activity 1 sampling results indicated three areas with potential groundwater plumes containing radiological and chemical contaminants at levels significantly above levels of environmental concern.

The vertical extent of groundwater contamination has not been defined, nor has the potential for along-strike flow if deep groundwater is contaminated.

Tritium contamination, which is widespread in trench leachate, was found in water in the EWB and in a drainageway exiting the EWB at concentrations above human health criteria. The source and migrational significance of this contamination have not been identified.

The significance of surface water contamination and transport have not yet been determined.

ONGOING/PLANNED INVESTIGATIONS

Fate and Transport Analysis and the Baseline Human Health Evaluation are still under development. As these elements are refined, they may point to additional data needs.

Based on the current understanding of WAG 6, the following data analysis/acquisition activities are planned:

- o The results of ongoing/recently completed investigations will be incorporated with the data available herein (see Section 1.0)
- o Installation of four deep (75-ft to 150-ft) monitoring wells is planned to determine whether deep groundwater is contaminated and, if so, the extent of flow in deeper portions of the shallow aquifer
- o Additional soil gas measurements and placement of approximately six(6) additional water quality wells will be used to further evaluate contaminant plumes in the saturated zone
- o As wells are installed in suspected plume areas, selected soil samples will be analyzed to confirm that subsurface soils contamination is confined to the trench areas
- o Groundwater sampling and analysis will be repeated for both new and existing water quality wells to refine an understanding of seasonal fluctuations in water quality and to refine an understanding of the interactions between ground and surface water
- o Information on surface water flow and contaminant concentrations will be obtained to assess the importance of this migration pathway
- o Sediment samples will be obtained from the EWB and selected drainages in WAG 6 and analyzed to determine whether sediments represent a potential source of long-term contaminant migration, and therefore require remediation
- o Further evaluation of the pasteurella-like bacteria found in some of the WAG 6 groundwater samples is required. A sampling plan to determine if the bacteria is unique to WAG 6 is presently being developed and will be issued to EPA in early spring 1990 for review.

1.0 INTRODUCTION

A RCRA Remedial Facility Investigation was initiated in December 1988 for ORNL Waste Area Grouping (WAG) 6. This investigation is a portion of a program referred to as the ORNL Remedial Investigation/Feasibility Study (RI/FS), which includes investigation, assessment, and evaluation of corrective measures for environmental releases.

This Site Characterization Summary report presents all data collected, validated, and available as of November, 1989 and the findings of the initial Phase 1 RFI activities conducted from December 1988 to June 1989 at WAG 6 by the Bechtel National, Inc. (BNI) Team under direction from Martin Marietta Energy Systems, Inc. (Energy Systems). Phase 1, Activity 1 was conducted according to the WAG 6 RFI Plan (BNI, 1989), with some activities and the schedule modified under the direction of the ORNL Technical Review Committee (TRC) (BNI, 1989). The U.S. Department of Energy (DOE) established a TRC to address implementation of the RFI field activities outlined in the RFI Plan. This committee was comprised of ORNL, and BNI representatives, and was chaired by DOE/Oak Ridge Operations (ORO). Results of evaluation of technical issues and recommendations submitted by the committee were reviewed by the committee chairman with the final work plan determination made by the chairman.

The information in this report is organized into Sections which focus on the following topics: The scope and objective of the RFI are discussed in Section 1.1 with information on project phasing contained in Section 1.2. Section 2.0, Site Description and Background, includes a site description and summarizes the background data available prior to the start of the RFI. Section 3.0, Site Investigation, briefly describes the field activities undertaken during the Phase 1, Activity 1 site investigation. Technical memoranda (which describe each field activity in

detail) are referenced in this section and are located in Appendix A of this report. Section 4.0, Physical Characteristics, discusses the physical characteristics of the site, including topography, surface features, geology, surface water hydrology, soils, and hydrogeology. Section 5.0, Nature and Extent of Contamination, provides information on the form and distribution of contamination in four media, including groundwater, soil, surface water, and sediments. Section 6.0, Contaminant Fate and Transport, provides the methodology to perform fate and transport analysis at WAG 6. Section 7.0, presents selected components of the WAG 6 baseline human health risk assessment and also provides identification of ARAR's and corrective action alternatives. Section 8.0, Preliminary Identification of Technologies, identifies remedial technologies that are applicable to site closure and remedial alternatives at WAG 6. Section 9.0, Conclusions and Recommendations, provides conclusions of the Phase 1, Activity 1 RFI findings and recommendations for future activities. The remainder of this section (1.0 Introduction) provides information on the regulatory setting that mandated the initiation of the RFI process at ORNL.

ORNL Regulatory Setting

ORNL is one of three principal facilities established on the DOE Oak Ridge Reservation (ORR) under the World War II atomic weapons project in 1942 and 1943. The primary role of ORNL has changed from process development support for the nation's weapons program to a primary focus on the development of civilian uses of nuclear technologies and widespread application of non-nuclear energy sources (National Research Council, 1985). The facility is currently operated by Energy Systems for DOE.

Throughout the operational history of ORNL, generation of radioactive, hazardous, and mixed (radioactive and hazardous) wastes has occurred as a result of routine facility operations.

In general, these wastes have been generated by the following types of facilities:

- o Radioisotope production facilities
- o Hot cells and pilot plants
- o Accelerators
- o Reactors
- o Analytical and research laboratories

Wastes have been disposed by various methods, including shallow land burial using trenches and auger holes and by hydraulic fracturing of subsurface geologic formations for liquid and/or sludge disposal. Additionally, certain wastes have been placed in above- and below-ground storage in tanks, surface impoundments, vaults, and concrete bunkers. A very high fraction (approximately 90 percent) of the radioactive and organic solvent wastes were disposed in a small, localized area of WAG 6.

To provide a comprehensive and cohesive approach to addressing the cleanup of areas or facilities where past or present activities have resulted in contamination of facilities or the environment, ORNL developed the Remedial Action Program (RAP). The RAP provides comprehensive management of all radioactively and chemically contaminated ORNL sites until final closure of the sites.

Initially, RAP guidance for accomplishing these tasks was provided by DOE Orders 5820.2, "Radioactive Waste Management," and 5480.14, "Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Program." To the extent possible, the guidance follows regulations issued by EPA pursuant to RCRA. DOE Order 5480.14 set a timetable for bringing DOE facilities into compliance with the CERCLA, which initiated remedial response activities. Compliance milestones and completion dates were integrated into an overall long-range environmental plan for ORNL (BNI, 1989). However, in April 1986, EPA issued a permit

for the DOE/ORNL Hazardous Materials Storage Area, Building 7652. This permit initiated an EPA plan to enforce regulatory requirements for ORNL remedial response activities through RCRA Section 3004(u), rather than through CERCLA. The primary objective of the 3004(u) program is to clean up releases of hazardous wastes or hazardous constituents from solid waste management units (SWMUs) at RCRA permitted facilities.

The 3004(u) corrective action program consists of the following four phases (EPA, 1986e):

Phase 1. The RCRA Facilities Assessment (RFA), which identifies releases or potential releases requiring further investigation.

Phase 2. The RFI, which characterizes the extent of releases.

Phase 3. The Corrective Measures Study (CMS), which determines the need for, and extent of, remedial measures. This step includes identification of appropriate remedies for identified problems.

Phase 4. The Corrective Measures Implementation (CMI), which designs, constructs, operates, and monitors performance for the measures selected.

ORNL RFA (Phase 1)

The RFA for ORNL was submitted to EPA in March 1987 (ORNL, 1987). Approximately 250 sites were identified as known active or inactive SWMUs or contaminated facilities, or as potential sources of continuing contaminant release to the environment. Included in this list are waste collection and storage tanks, solid waste storage areas (SWSAs), waste treatment units, impoundments, and leak and spill sites. Although cleanup of releases from some of the sites are not enforceable under RCRA Section 3004(u) (e.g., Surplus Facilities sites), they are included in the list to provide a comprehensive inventory of all ORNL sites that may represent actual or potential sources of continuing release to the environment. Only those actual or

potential sources regulated under RCRA are referred to collectively as SWMUs.

Because of the large number of sites and the interaction among many of them, ORNL proposed to EPA that the SWMUs be combined into WAGs that were geographically contiguous or within defined hydrologic units. The WAG concept was developed to group the remedial action sites into manageable units that could be handled separately.

The combining effort produced 20 WAGs, which are generally watersheds that contain contiguous or similar operating facilities and remedial sites.

RI/FS

For the ORNL RI/FS, a separate RI and Alternatives Assessment (AA) will be performed for each WAG except WAG 6, for which an RFI and CMS will be conducted. These activities are detailed in the SWSA 6 Closure Permit Application (BNI, 1988a).

Waste Area Grouping 6

WAG 6 includes three SWMUs: SWSA 6 (SWMU 6.1), the Emergency Waste Basin (EWB) (SWMU 6.2), and the Explosives Detonation Trench (EDT) (SWMU 6.3). The EWB is physically located outside the boundary of WAG 6; however, it is still considered to be a portion of WAG 6. SWSA 6, which has received low-level radioactive, chemically hazardous, and biological wastes, occupies the largest area within WAG 6 and is the principal source of contaminants. The EDT, which is located in the eastern part of WAG 6, is now backfilled and covered. The trench measured about 15 by 5 by 4 ft and was used to detonate explosives and shock-sensitive chemicals such as picric acid, phosphorus, nitromethane, hydrogen peroxide, and ammonium nitrate. The EWB was constructed as a LLW or process waste

holding basin to be used whenever ORNL was unable to release wastes to White Oak Creek (WOC). The basin, which encompasses about 2 acres and has a volume potential of 15 million gallons, was constructed in 1961-1962, but has reportedly never been used for its intended purpose.

1.1 RFI SCOPE AND OBJECTIVE

The scope of the RFI was designed to supplement existing information to determine whether or not the SWMUs in WAG 6 represent a significant hazard to human health and to support assessment of potential remedial alternatives during the CMS.

The objectives of this investigation are summarized as follows:

- o Evaluate the adequacy of existing data and determine additional data requirements
- o Evaluate those data necessary to support the CMS and to determine the nature and extent of contamination
- o Evaluate potential route(s) of contaminant release and migration
- o Quantify the potential impact and risks to human health from actual or potential release of contaminants from the site

1.2 PROJECT PHASING

The WAG 6 RFI process is based on a phased approach. In a phased approach, the data are collected in stages. The initial RFI activities (Phase 1) focused on developing a general understanding of the site. Subsequent phases can be focused on filling in data gaps. This phased approach allows for the identification of data needs early in the process and ensures sufficient information is gathered as required for preparation of the risk assessment.

Phase 1 activities initially focused on evaluating existing data from previous investigations performed on the site. Based on

this evaluation, additional data needs were identified to determine the nature and extent of contamination. Phase 1 activities included nondestructive surveys (i.e., radiological scans, soil gas studies, and electromagnetic investigations). Additionally, soils, sediments, surface waters, and groundwaters were sampled and analyzed for chemical, radiological, and biological contaminants. Phase 2 data requirements will be based on the findings of Phase 1.

Soil borings were placed to identify zones of contaminant movement from the trenches and to intercept and test the following:

- o Relict zones of surface drainage prior to SWSA 6 construction
- o Known areas of trench "bathtubbing" during heavy rainfall
- o Areas along geologic strike (i.e., east-west) from trenches and auger holes.
- o Soils adjacent to trenches or auger holes containing known relatively large amounts of contaminants
- o Areas away from the immediate trench perimeters that have been identified in previous studies as "hot spots"
- o Areas in which trenches intersect the water table/areas of alluvial soils (which tend to correlate with criterion 1 and 2, above)

The reevaluation of the original plan by the TRC resulted in deleting two boring locations and relocating nine others.

The TRC's review of the proposed groundwater monitoring system resulted in a significant change in the initial RFI Plan. Based on research data collected by ORNL Environmental Sciences Division (ESD) staff, a decision was made to replace the RFI Plan proposed groundwater monitoring well system with one that focused on the shallow stormflow zone. ORNL data indicated that a significant portion (i.e., 90 to 95 percent) of the subsurface flow occurs in this zone with discharge to surface waters with

little vertical migration predicted. Additionally, ORNL has installed regulatory compliance wells which will allow for detection of off-WAG migration of contaminants. As a result, the plan was revised to concentrate on this shallow zone during the Phase 1, Activity 1 effort.

Due to an exceptionally wet summer, base flow or the equivalent of low water table surface and subsurface water samples were acquired too late during Phase 1, Activity 1 to be evaluated for incorporation into this report. Additionally, the ORNL sub-cap water table data and the fourth quarter ORNL groundwater data were not available for evaluation. Furthermore, background samples for soils, surface waters, and groundwaters will be obtained during the WAG 1 investigation. This activity will precede the WAG 6 Phase 1, Activity 2 investigation. Results from this activity will determine average background levels that will be applicable for all future RIs and RFIs presently planned for the Melton and Bethel Valley portions of the ORNL reservation.

All of the above mentioned data will be evaluated and incorporated into the final RFI Report for WAG 6.

2.0 SITE DESCRIPTION AND BACKGROUND

This portion of the Site Characterization Summary Report is divided into three sections. Section 2.1 provides a general description and background information on WAG 6. Section 2.2 presents a summary of the history of each SWMU located within WAG 6. Section 2.3 provides a brief review of previous investigations conducted at WAG 6.

2.1 SITE DESCRIPTION

WAG 6 is located in Roane County, Tennessee, on the ORR, approximately 10 mi southwest of the City of Oak Ridge (Figure 2-1). The ORR contains three facilities established by DOE: ORNL, the Y-12 Plant, and the Oak Ridge Gaseous Diffusion Plant (ORGP) (Figure 2-2). WAG 6 is part of ORNL and is located approximately 2 mi southwest of the ORNL Main Plant Area. WAG 6 is bordered on the south by White Oak Lake near White Oak Dam and on the west by State Highway 95. White Oak Lake and White Oak Creek (WOC) are part of WAG 2, which extends into the ORNL Main Plant Area. The WAG 6 location in relation to other ORNL WAGs is shown in Figure 2-3.

WAG 6 is in Melton Valley, between Haw Ridge on the north and Copper Ridge on the south. The topography consists of gently to moderately sloping land, which drains to a tributary of WOC on the east and to White Oak Lake on the south (Figure 2-4).

WAG 6 contains three SWMUs: SWSA 6, the EWB, and the EDT. The location of the individual SWMUs is shown in Figure 2-5 and is described in the following sections.

SWSA 6 is the largest SWMU within WAG 6, comprising approximately 68 acres, with approximately 15 acres used for waste disposal. SWSA 6 has received low-level radioactive, chemical, and biological wastes. Disposal operations began in 1969, and

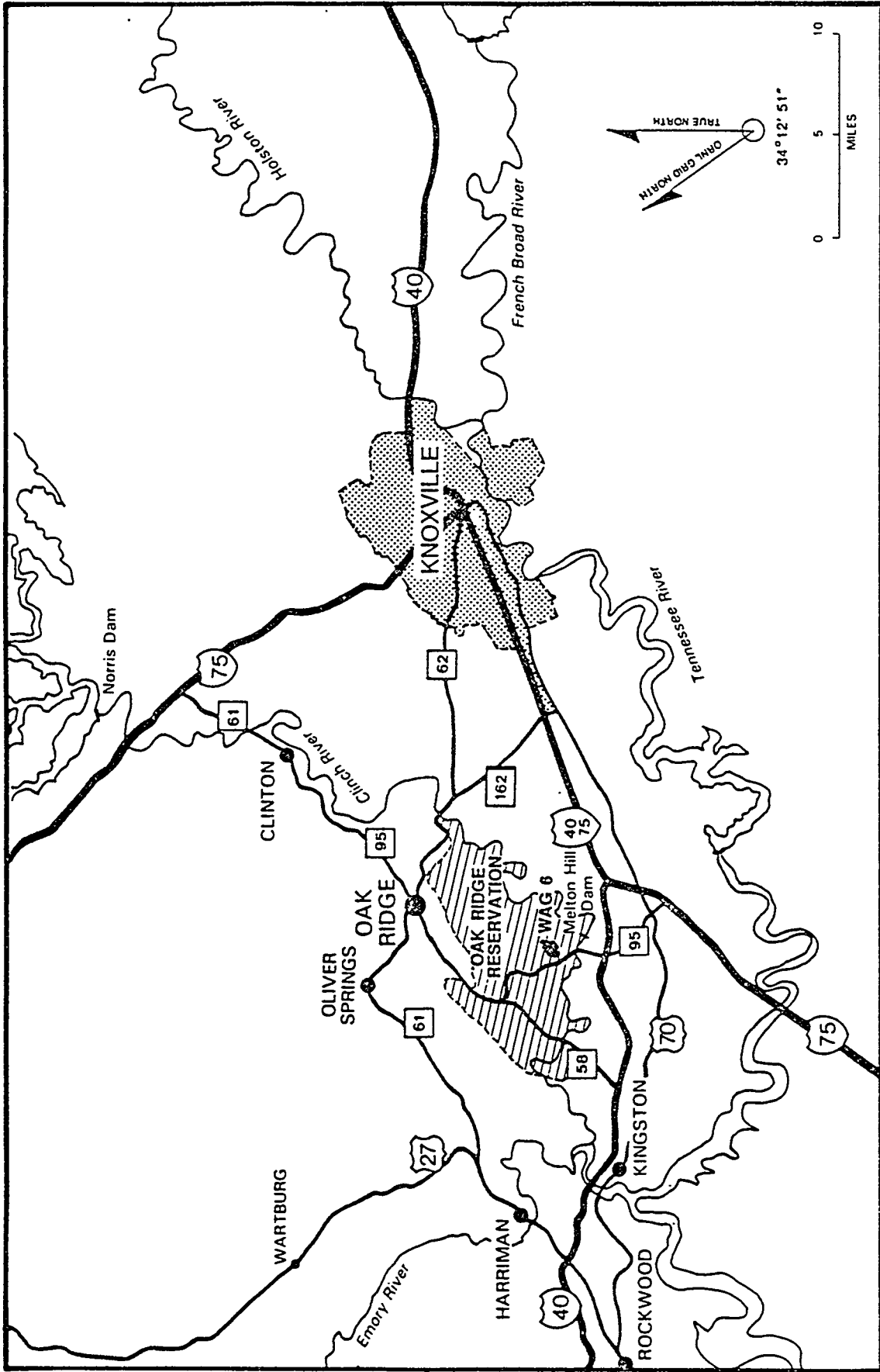


FIGURE 2-1
 MAP OF THE OAK RIDGE, TENNESSEE AREA SHOWING
 LOCATION OF THE OAK RIDGE RESERVATION

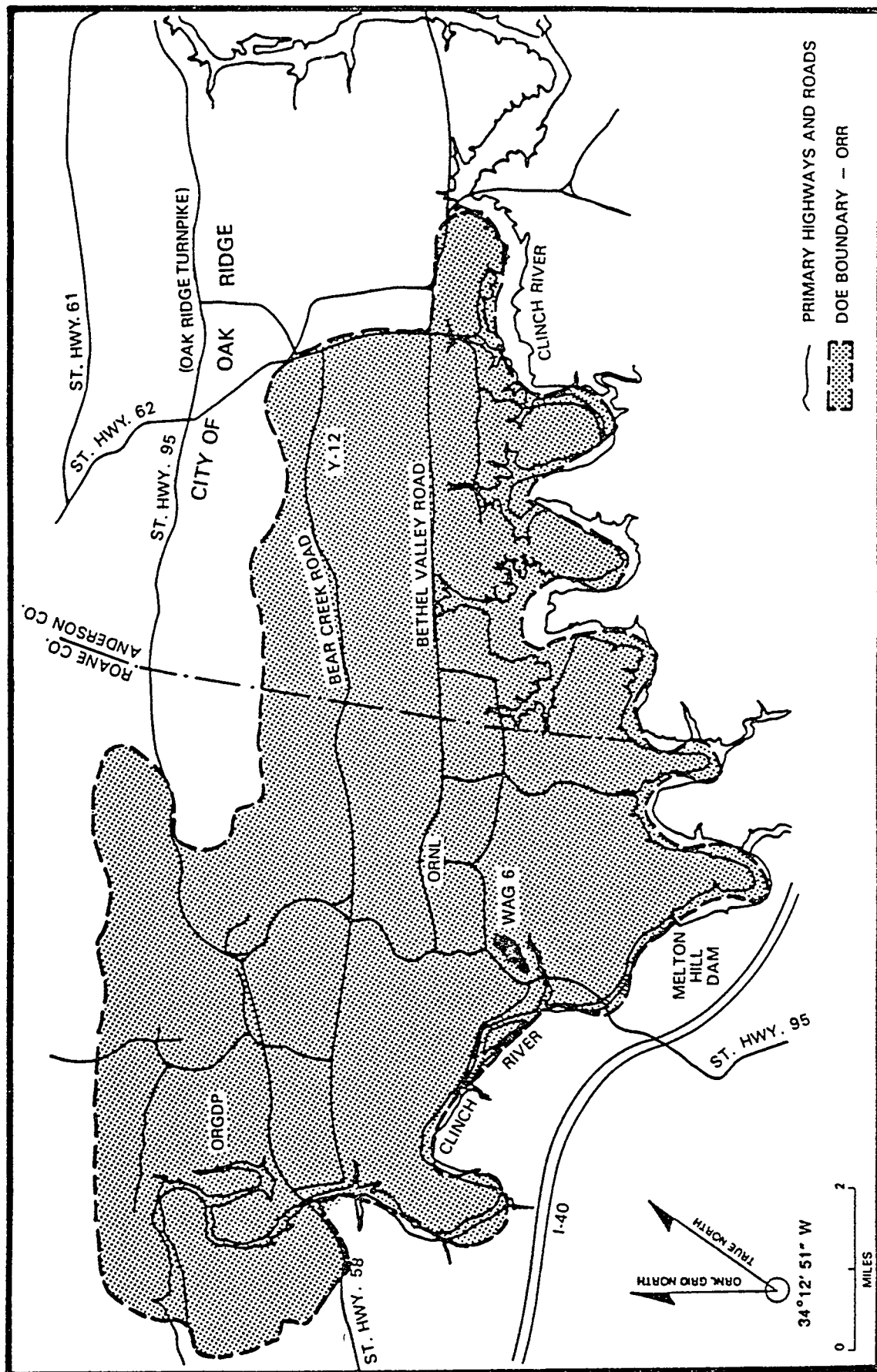


FIGURE 2-2
MAP OF THE DOE OAK RIDGE RESERVATION

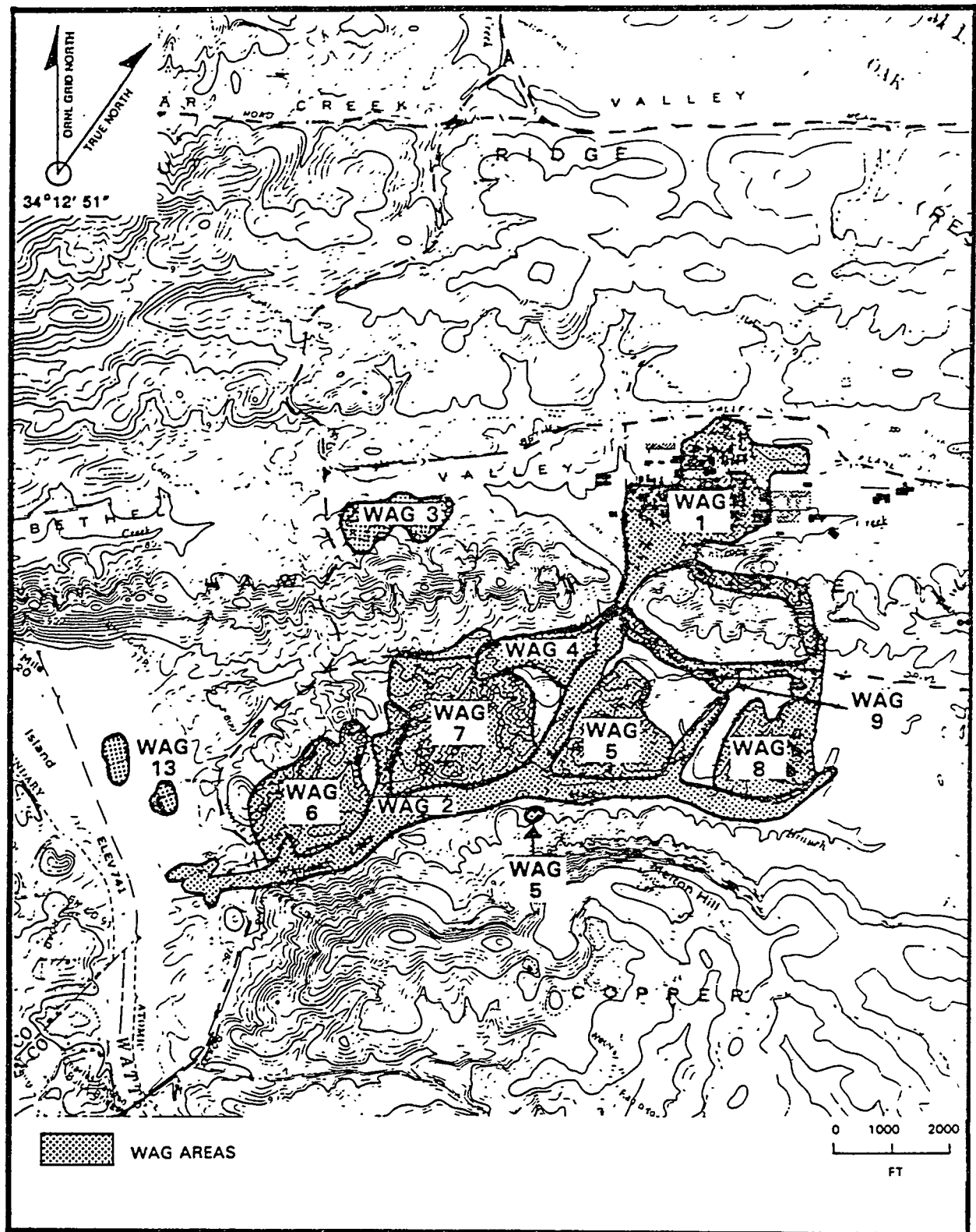


FIGURE 2-3
LOCATION OF WAG 6 TO OTHER ADJACENT ORNL WAGs

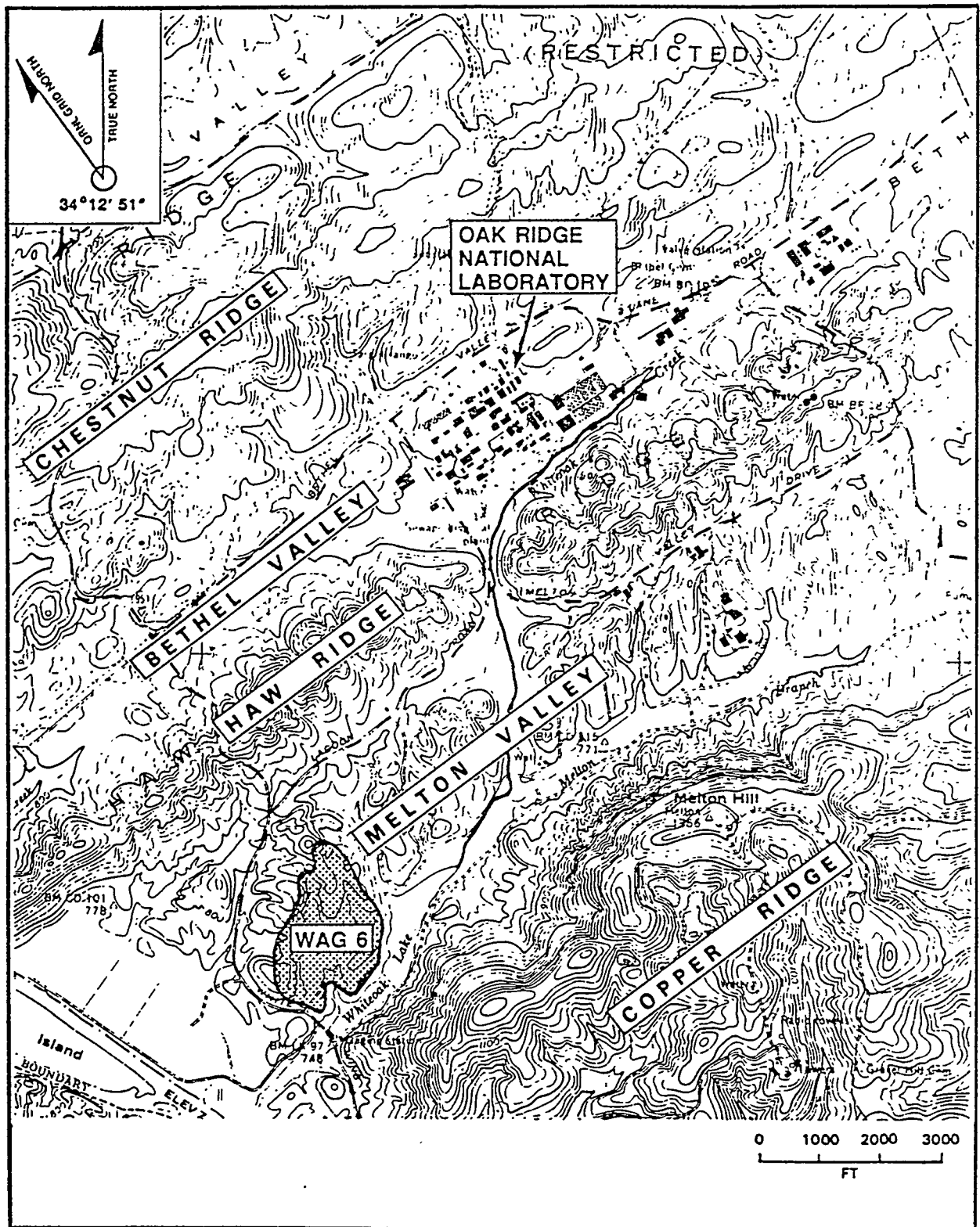
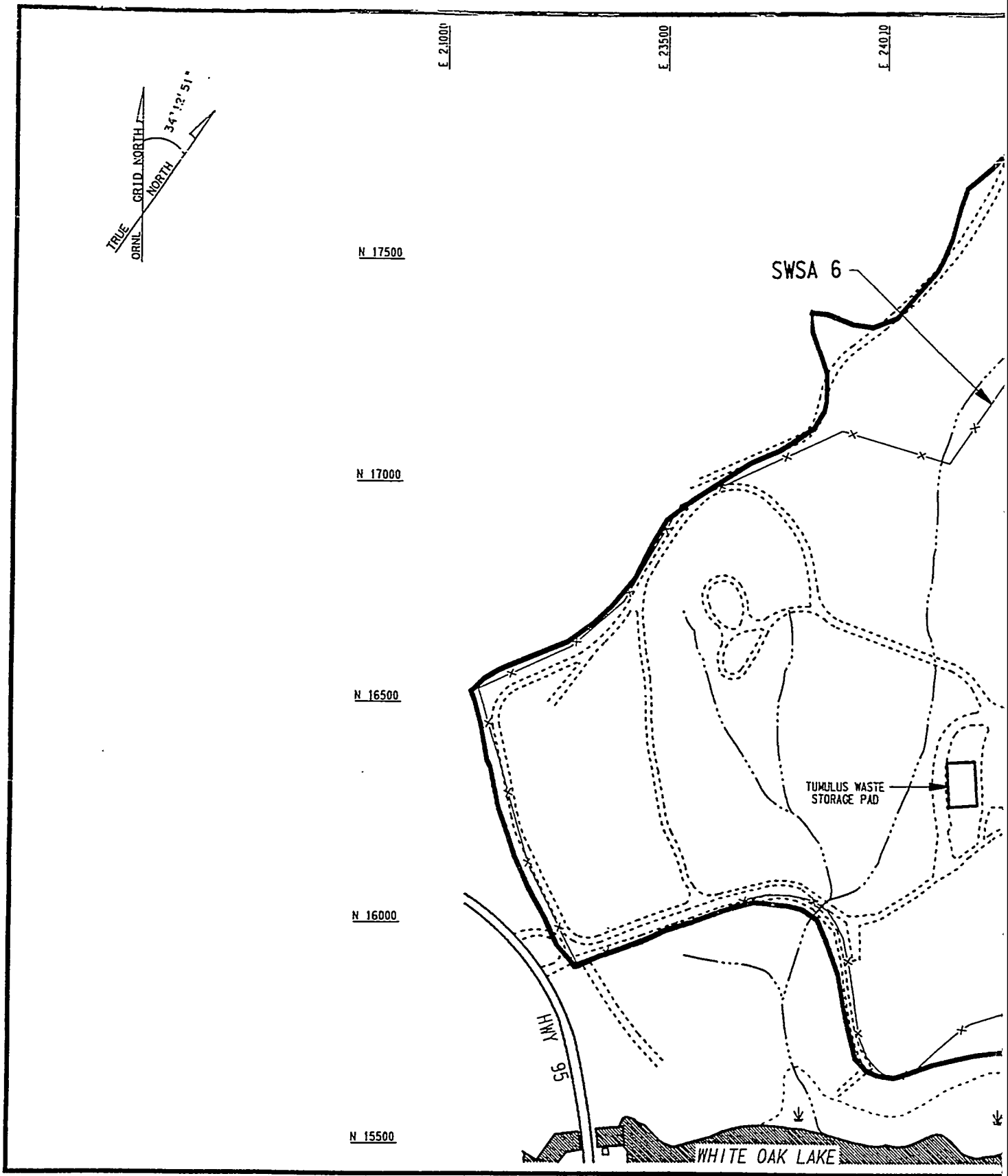


FIGURE 2-4
TOPOGRAPHIC MAP OF ORNL
AND THE SURROUNDING AREA



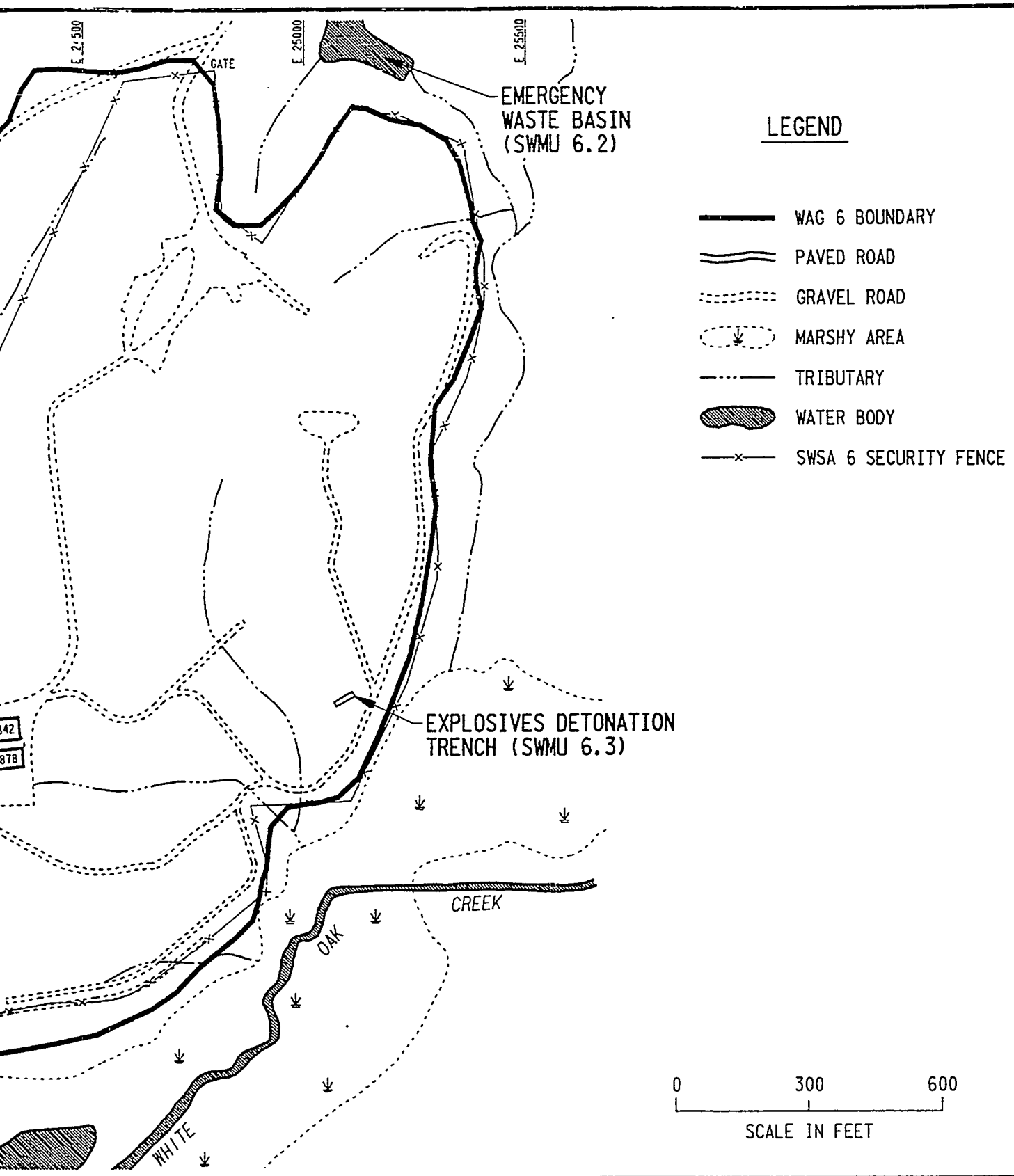


FIGURE 2-5
LOCATION OF WAG 6 SOLID
WASTE MANAGEMENT UNITS
2-6

disposal of LLW is ongoing. Prior to 1986, wastes at SWSA 6 were disposed in over 510 trenches and 490 auger holes. The trenches were used for disposal of large waste packages and assorted bulky items. Auger holes were used for small items with considerable surface activity requiring immediate closure for shielding purposes (Davis et al., 1989). Dimensions of trenches used at SWSA 6 were highly variable depending on the topography and trench type. They generally were 50 ft long by 10 ft wide by 13 to 20 ft deep. Beginning in 1975, trench depth was limited to approximately 15 ft or less, with the floor of the trench being at least 2 ft above the documented high water table. Minimum spacing between trenches was 5 ft. When the waste level reached approximately 3 ft below the top, the trench was backfilled with soil from the excavation of the next trench. The area was seeded to minimize erosion (ORNL, 1987).

Auger holes were generally located in the higher elevations of SWSA 6. Diameters ranged from 1 to 4 ft, with depths to 20 ft. In June 1986, the use of unlined trenches and auger holes was discontinued, and waste disposal was restricted to LLW (i.e., no chemical waste). Wastes are now disposed in GCD silos consisting of cylindrical concrete silos with top and bottom caps, placed below grade in a vertical orientation (Baldwin et al., 1989). Dimensions included 6-in. thick concrete walls and an 8-in. thick steel reinforced concrete top and bottom. The majority of the silos are also equipped with a 3-in. diameter polyvinyl chloride (PVC) monitoring well on the inner wall of the silo for detection and sampling of waste leachate in the silos.

The silos were constructed using three different techniques. The initial 12 silos were constructed using precast concrete drainage pipe. Four of the pipes were placed adjacent to one another in a trench. The trench around the pipes was then backfilled, and a steel-reinforced concrete bottom was poured into each silo. The joint between the concrete silo walls and floor was sealed with tar (Baldwin et al., 1989).

The second construction technique, which was used to construct 24 silos, consisted of using two diameters (8-ft and 9-ft) of corrugated metal pipe as forms for pouring the concrete sidewalls. The two pipes were aligned vertically, positioned concentrically, and attached with welded struts. The bottoms were formed by pouring a steel-reinforced concrete floor and sealing the joint between the inner corrugated metal pipe and the concrete floor with tar.

Early monitoring of the silos indicated that some water was present in the silos, and the integrity of the joint between the concrete floor and sidewalls was suspected (Baldwin et al., 1989). This resulted in development of a third construction technique. As in the previous construction method, corrugated metal piping was used as forms for pouring the concrete sidewalls. However, the inner of the two pipes was raised approximately 1 ft above the outer pipe before being welded in place. The floor was then poured first, using the outer metal pipe as its sidewall. This technique results in a concrete-to-concrete joint.

2.2 SITE HISTORY

The following sections present a summary of the site histories of the three SWMUs in WAG 6. The site histories present information on construction, operation, and maintenance activities.

2.2.1 SWSA 6 (SWMU 6.1)

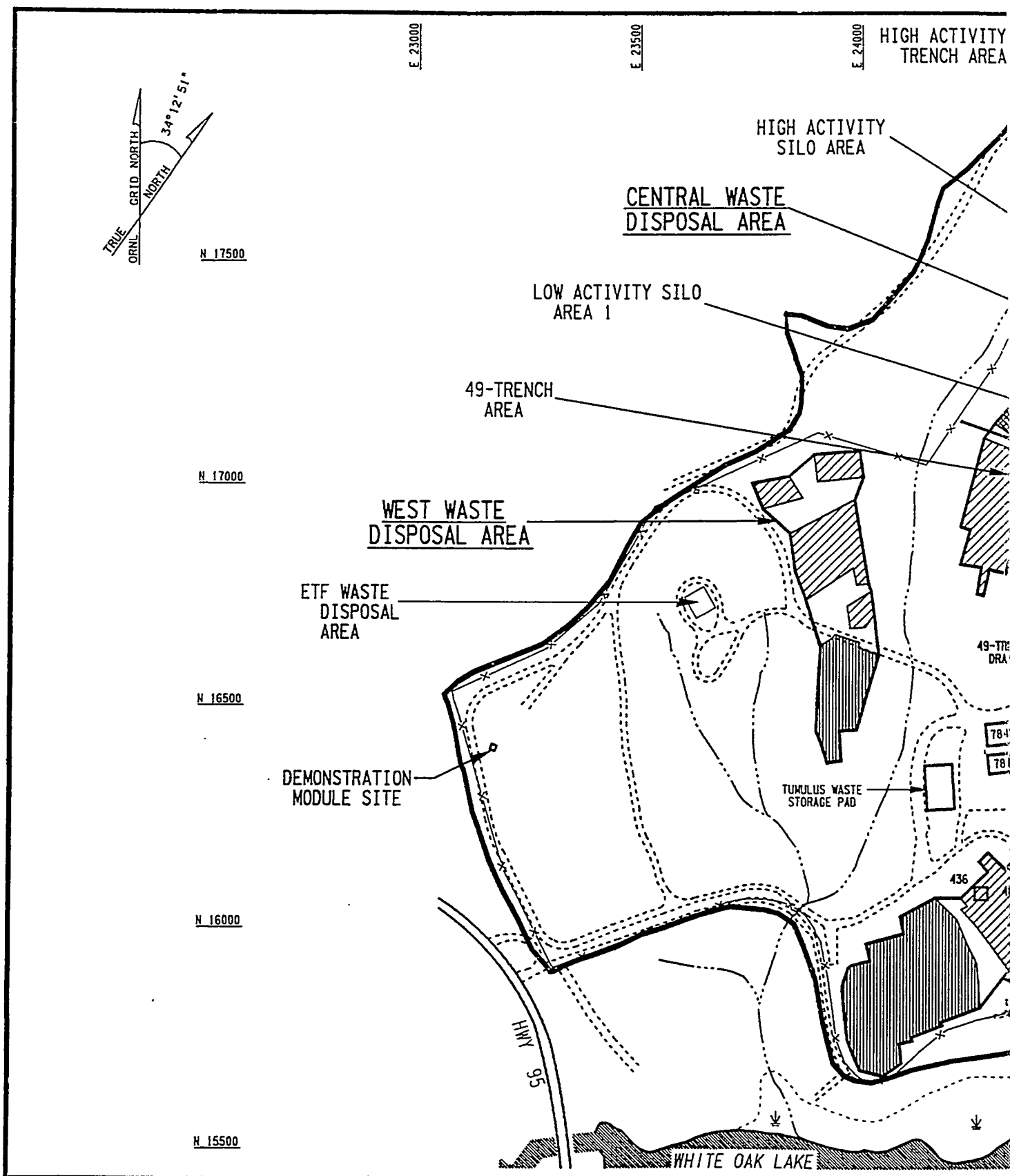
SWSA 6 was opened for limited disposal operations in 1969 and began full-scale operations in 1973. SWSA 6 received wastes (radioactive and chemical) from every operational activity conducted at ORNL. The wastes included solvents, scintillation liquids, laboratory glassware and equipment, protective clothing, worn-out or obsolete mechanical equipment, construction materials, asbestos, filter media and resins, animal remains, and

contaminated earth. Currently, only LLW is disposed in SWSA 6. No chemical wastes have been disposed there since April 1986. Prior to 1986, packaging of these wastes was highly variable, ranging from plastic bags to stainless-steel drums to no containerization at all (IT, 1986).

Trenches are classified based on the form of disposed waste: high activity (unlined), low activity (unlined), biological, asbestos, baled, fissile, high-activity concrete lined, or low-activity concrete lined. A map indicating the locations of the various trench types is shown in Figure 2-6. The demolition landfill, which is still active, is used for disposal of shredded radiological contaminated (suspect) waste.

The high-activity (unlined) trenches are concentrated in two areas at the northern edge of the site where the height above the water table is greatest. These trenches occupy approximately 2 acres, or 3 percent of the total area of SWSA 6. High-activity trenches were used for disposal of waste with a reading on the surface of the container equal to or exceeding 200 mR/h. This waste generally contained beta-gamma activity and/or nonfissile alpha activity. However, at least two of the trenches (numbers 120 and 346) contain scintillation fluids composed primarily of xylene and toluene (ORNL, 1986). After being placed in the trench, wastes were covered with sufficient soil to lower the surface radiation reading to 100 mR/h or less. The period of active disposal for each trench was approximately 6 to 8 months.

Low-activity (unlined) trenches occupy the most area in SWSA 6 and are second in number only to biological trenches. The low-activity trenches were used to dispose wastes with radiation readings on the surface of the container of less than 200 mR/h. These wastes included metal, wood, construction debris, concrete, paper, plastics, clothing, and lead shielding (IT, 1986). These trenches were usually active for 6 to 8 weeks. Before June 1985, wastes were simply dumped into trenches; after that



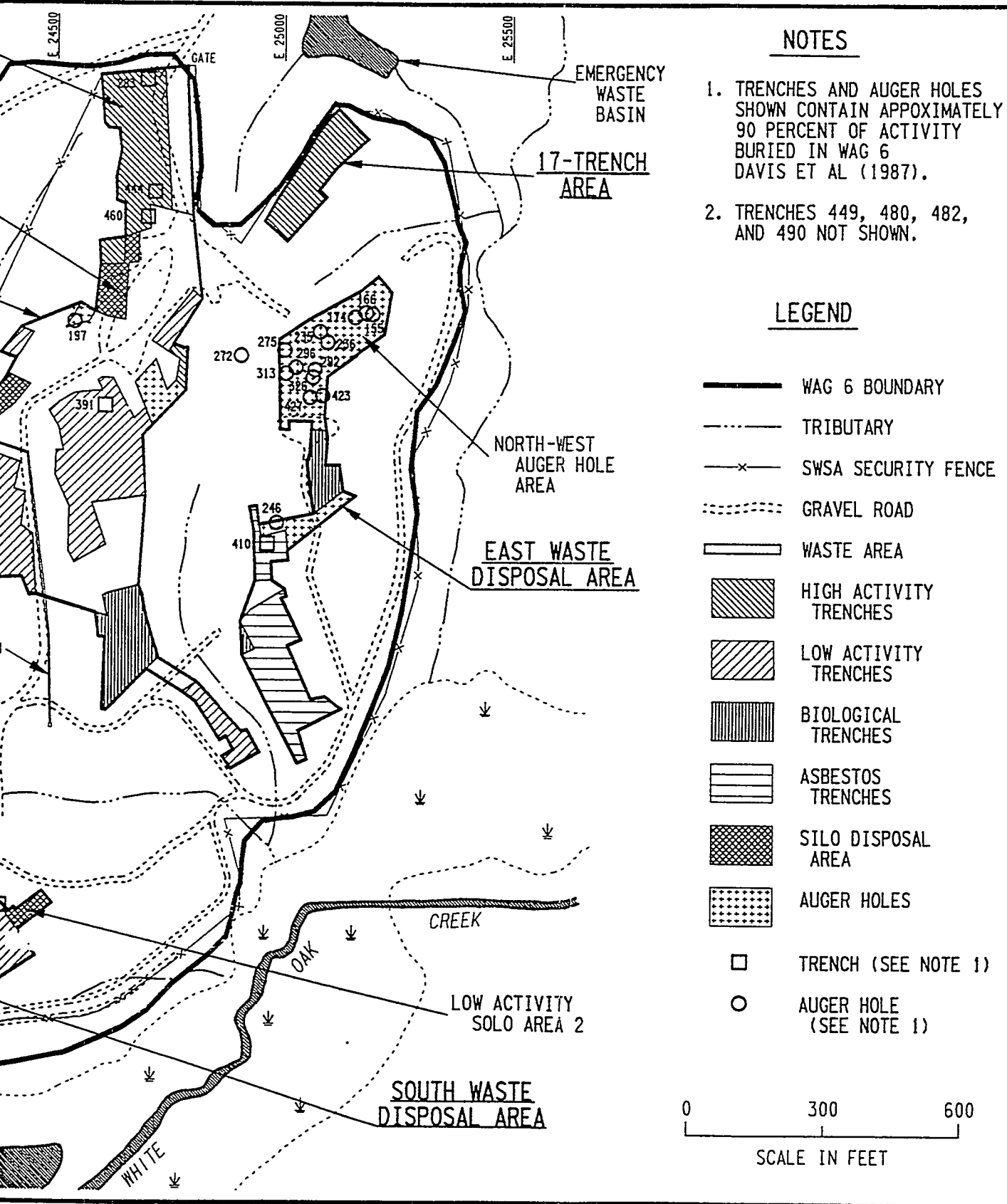


FIGURE 2-6
WAG 6 SOLVENT AUGER HOLE
AND BIOLOGICAL TRENCH AREAS

time, most waste was packaged in plywood boxes or 55-gal steel drums and stacked in the trenches.

Asbestos trenches, which occupy only 0.7 acre, or 1 percent of the total area of SWSA 6, received both radioactively contaminated and uncontaminated asbestos. These trenches were used infrequently, about once every 3 to 4 weeks, and the waste was covered with soil the same day (ORNL, 1986). To conserve trench space, metal dividers were placed about 8 ft apart to prevent fill dirt from spilling into unused portions of the trench.

Compacted bale trenches comprise about 0.15 acre, or 2 percent of the total area (ORNL, 1986). These trenches received compacted wastes (i.e., gloves, shoe covers, and blotter paper), which were not alpha radioactively contaminated and had a contact radiation reading of 200 mR/h or less. Wastes were compacted about twice a month into 10 ft³ bales, weighing approximately 650 lb. The compaction process resulted in a volume reduction of approximately 8 to 1.

The biological trenches comprise the largest group of trenches in SWSA 6, occupying approximately 3.2 acres, or 5 percent of the total area (ORNL, 1986). The trenches are distributed throughout four areas of the site, primarily in the central and southern portions of SWSA 6. As in the asbestos trenches, metal dividers were used to conserve space and prevent fill dirt from spilling into unused portions of the trench. Biological waste was disposed about once a week. Completed trenches were backfilled and seeded. The period of active disposal for each trench was approximately 6 weeks.

The biological trenches received materials from biomedical laboratories, including carcasses of experimental animals, bedding, excreta, gloves, and shoe covers. The waste is reported to be primarily low-activity, low-level, non-alpha contaminated,

less than 200 mR/h, with most waste being approximately 5 mR/h. The biological trenches also contain the largest volume of scintillation fluids (primarily xylene and toluene) in SWSA 6. Records indicate that between 1972 and 1976, over 12,500 gal of scintillation fluids may have been disposed in 35 biological trenches (ORNL, 1986).

Auger holes have been classified as high-activity, solvent, or fissile (Davis and Solomon, 1987). The auger holes, which comprise approximately 1.2 acres, or 1.7 percent of the total SWSA 6 area, are located in higher elevation areas of SWSA 6 (Figure 2-6). The holes are generally 1 to 4 ft in diameter, 20 ft in depth, and spaced approximately 3 ft apart. Three or four disposals were routinely made in each auger hole. Wastes were disposed in various sized containers up to 55-gal drums. After waste disposal, if the radiation reading was greater than 100 mR/h, soil was backfilled until the radiation level was reduced to 100 mR/h or less.

Fissile auger holes received wastes containing uranium-235, possibly mixed with other radionuclides, such as cesium-137, uranium-238, and strontium-90.

Unlined auger holes were used to dispose high-activity waste with radiation readings at the surface of the unshielded container equal to or exceeding 200 mR/h. Waste disposed in high-activity auger holes included other LLW not classified as fissile, such as cobalt and tritium. If a high-activity waste could physically fit into an auger hole, it was placed there.

Before 1980, solvent auger holes were used to dispose a variety of chemical wastes, some of which were radioactively contaminated. Exact volumes disposed are not known, but wastes included oils, cleaning solutions, alcohols, paint thinners, kerosene, jet fuel, acids, and sodium.

The demolition landfill, used for disposal of low hazard (suspect) waste, is also located within SWSA 6. This waste has no measurable surficial radiological contamination but has been judged by the generator to be radioactively contaminated above ORNL "Health Physics Material Transfer Clearance Tag" (free of radiation or other contamination hazards) limits or to be such that some areas cannot be surveyed (such as the insides of pipes). This landfill occupies approximately 5 acres and is located in the northeastern portion of SWSA 6. Waste is shredded to reduce its volume and when it is placed in the landfill, it is covered with soil.

As described in Section 2.1, LLW are disposed in GCD silos. (Currently, no chemical wastes are disposed in SWSA 6.) The GCD silos are located in three groups: two groups of low-activity silos, and one group of high-activity silos (Figure 2-7). Approximately 100 silos currently exist at SWSA 6.

A Closure Plan Permit Application for SWSA 6 (BNI, 1988a) was submitted in April 1988 to EPA and TDHE to meet regulatory requirements for initiating closure activities in SWSA 6 by November 1988 [40 CFR 265 Subpart G and TDHE Rule 1200-1-11.05(7)]. Initiation of closure of the RCRA-regulated areas will involve implementation of an interim corrective measure (ICM) and siting of a temporary cap and drainage controls as part of the overall closure of the SWSA. The closure plan was revised in August 1988 and subsequently approved by EPA.

SWSA 6 is also the site of several planned site operations, interim corrective actions, and remedial action technology demonstration studies.

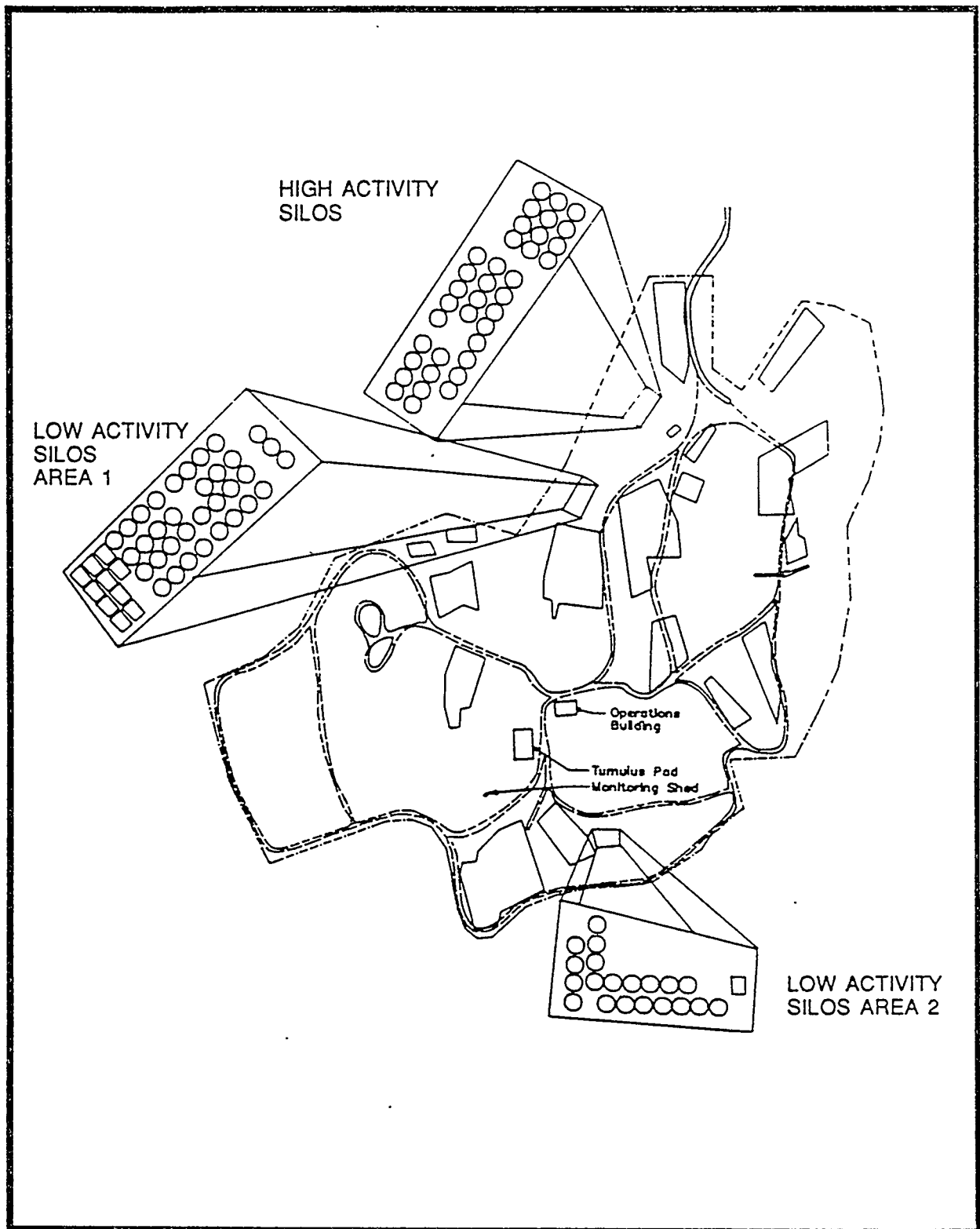


FIGURE 2-7
 PLAN VIEW OF SWSA 6 SHOWING LOCATIONS
 OF THE SILO AREAS IN RELATION TO
 EXISTING TRENCH AND AUGER HOLE AREAS

Planned Site Operations

The Tumulus Disposal Demonstration project is a two-phased project (Tumulus I and II) being conducted to evaluate the effectiveness of tumuli for above-ground disposal of LLW (Baldwin et al., 1989).

The Tumulus I facility, located in the central area of SWSA 6, consists of two layers of concrete vaults or casks containing LLW placed on a concrete pad and overlain by a cap. The pad is approximately 105-ft by 65-ft and is constructed of steel-reinforced concrete. Directly beneath the pad is a leak detection layer consisting of free draining stone underlain by a synthetic membrane.

During implementation, the vaults will be transferred from the existing temporary storage buildings and will be stacked two-high on the pad. The top of the second layer of vaults will be approximately 11 ft above the surface of the pad. Loading of Tumulus I is expected to be completed in late 1990.

The Tumulus II facility is to be constructed just north of Tumulus I. The design is similar to Tumulus I, although the dimensions are slightly smaller (60-ft by 90-ft). Construction of this facility began in January, 1990 with loading operations anticipated to begin in July, 1990 (Baldwin et al., 1989). The tumulus will be overlain by a multi-layered cap to be specified as part of the CMS.

An area in the southwest portion of SWSA 6 has been set aside for the location of an Interim Waste Management Facility (IWMF). This facility, which is expected to begin operations in September 1991 and close in September 1996, will consist of up to six tumulus pads measuring approximately 4,500 ft² (Baldwin et al., 1989).

Interim Corrective Actions

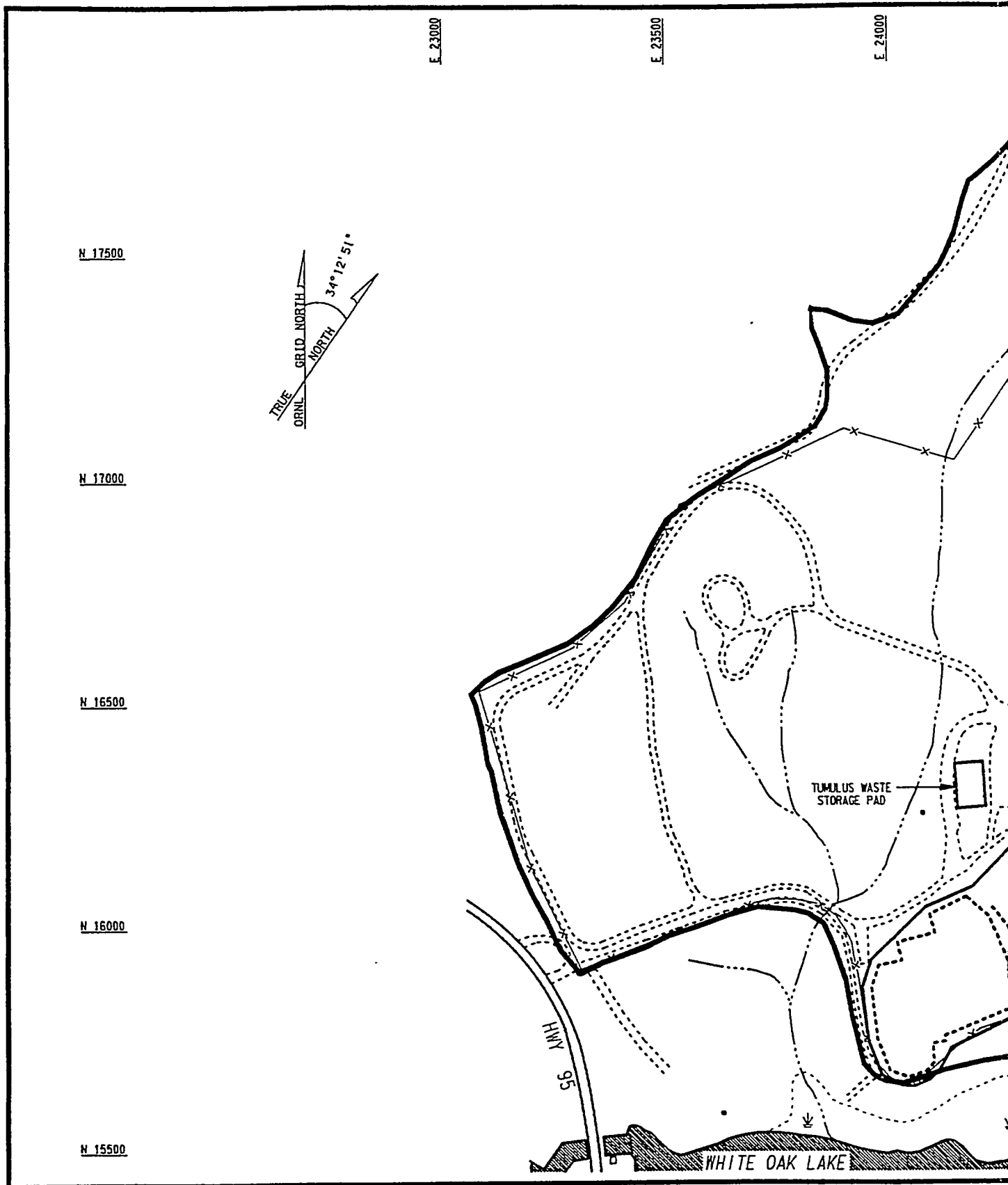
In an attempt to alleviate infiltration in an area of SWSA 6 known as the 49 Trench area, the area was sealed with a bentonite cover in 1976. The seal was covered with soil and seeded to prevent erosion. However, water was still observed in the underlying trenches (ORNL, 1986). In 1983, a French drain designed to prevent lateral movement of groundwater into trenches was installed in the 49 Trench area. The drain surrounded the trenches on the north and east sides and was installed at a maximum depth of about 30 ft (Davis and Stansfield, 1984).

Several trenches in close proximity to the drain have been dewatered, and there has been a general lowering of the groundwater table. Water contour maps show a significant change in groundwater flow direction, which is now toward the east leg of the drain. Maximum draw down is approximately 12 ft in the northeast corner of the site where the drain legs intersect (ORNL, 1986).

The Closure Plan for SWSA 6 required the installation of a low permeability cap over waste disposal areas that received RCRA regulated wastes as an ICM. The cap was installed during November 1988 to May 1989 and was designed to reduce surface water infiltration into the waste disposal areas. The cap consists of 80-mil, high-density polyethylene, which is resistant to ultraviolet light. Design life of the ICM cap is 5 years. The locations of the capped areas are shown on Figure 2-8.

Remedial Action Technology Demonstrations

ORNL has been investigating improved shallow land burial technology for LLW in humid environments. The Engineered Test Facility (ETF), a field-scale demonstration site, has been established in SWSA 6 to carry out these studies. Originally,



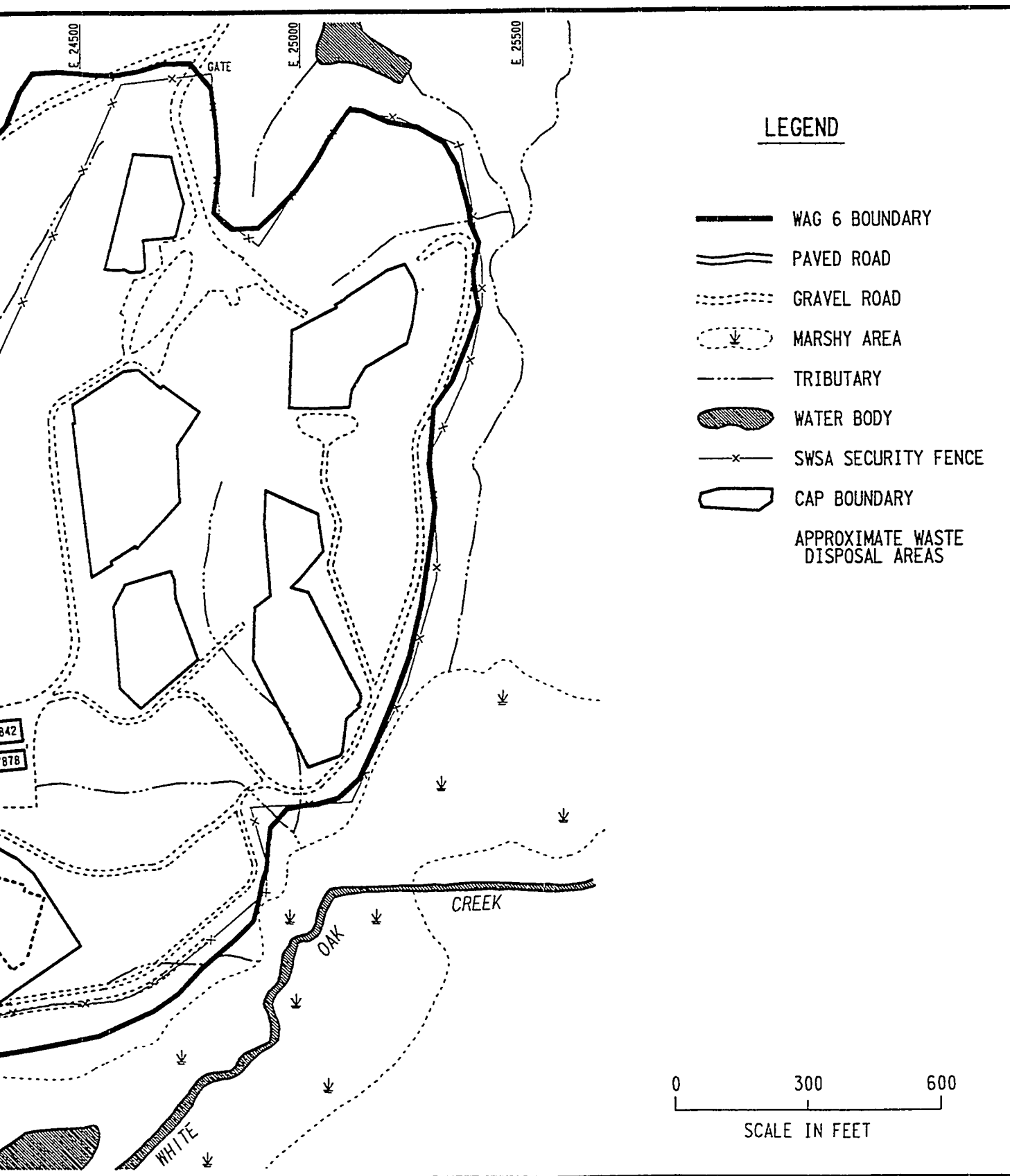


FIGURE 2-8
LOCATION OF WAG 6
ICM CAPS

the investigations were to focus on waste grouting prior to cover emplacement and waste isolation with trench liners to prevent the waste from contacting water and thus minimize waste leaching (Davis et al., 1984). The grouting demonstrations were eventually conducted elsewhere as discussed later in this section.

The ETF has been characterized to construct a hydrologic model based on geology, soils, and hydrology (Davis et al., 1984). Site characterization activities were initiated in 1981. Much emphasis was placed on geological characterization at shallow depths where the wastes lie. Radionuclide, chemical, and physical properties were determined using core samples taken nearby at depths ranging from 16 to 115 ft.

Field studies of dynamic compaction and trench grouting have also been conducted in SWSA 6. Spalding, Hyder, and Munro (1985) excavated three pilot-scale trenches (349, 350, and 351) measuring 10 ft by 10 ft by 5 ft. Each trench was fitted with eight PVC well casings and a central grout injection well. The trenches were filled with suspect solid waste including concrete blocks, tires, pipes, discarded equipment, wooden pallets, shipping cartons, and paper and backfilled with soil. To measure the hydraulic conductivity of the soils, four boreholes were placed around each trench.

Trenches 349 and 350 were grouted with sodium silicate in August and September 1982, respectively; Trench 351 was grouted with acrylamide in October 1982. The three trenches were situated so that they had different depths to groundwater. Trench 349 penetrated the water table so wastes were saturated for most of the year; Trench 350 was above the seasonal high point of the water table, and Trench 351 was intermediate between the two.

In August 1986, particulate grout was injected under pressure into Trench 150 as a remedial action demonstration to assess the

effect of this type of grouting on trench subsidence and radionuclide behavior (Spence, Godsey, and McDaniel, 1987). Besides the benefit of filling large voids and preventing subsidence, particulate grouts may immobilize and encapsulate most of the radioisotopes close to the waste, may redirect water flow paths away from the waste, and may offer the advantage of using natural materials that withstand the rigors of weather and time. Components used in this grout were Type I Portland cement (39 percent), Eastern Class C fly ash (55.5 percent), and bentonite (5.5 percent). A concrete mixing truck was used to mix the solids with water and the set retarder/dispersing agent. The grout was pumped through lances driven into the trench. A total of approximately 8,100 gal of grout, which represents about 19 percent of the total trench volume and most of the void volume, was successfully injected into Trench 150.

Trench subsidence is a major problem in remediating shallow land disposal sites. Subsidence depressions not only create catchments for surface runoff and precipitation but also channel water into contact with buried waste. Furthermore, surface stability is necessary for almost all infiltration and intrusion barriers. Spalding (1986) conducted a demonstration in SWSA 6 to evaluate the degree of consolidation that could be achieved by dynamic compaction of a closed burial trench in a cohesive soil formation. Trench 271 in the northern portion of SWSA 6 was selected for this demonstration. Waste disposal records indicate that the trench was operational from March to June 1978, during which time about 880 ft³ of waste weighing approximately 8,500 lb were disposed. The waste consisted primarily of contaminated equipment, demolition debris, and dry solids, with a small amount of biological waste. Packaging was variable. The inventory of radioisotopes, totaling about 80 Ci, included mostly strontium-90, with smaller amounts of cesium-137, samarium-151, thorium-232, uranium-238, technetium-99, cesium-134, ruthenium-106, cerium-144, iridium-192, cobalt-60, iron-59, manganese-54, californium-252, curium-244, and tin-121.

Compaction was accomplished by repeatedly dropping a 4-ton, steel-reinforced concrete cylinder from heights of 12 to 25 ft using the whipline of a 70-ton crane. The ground surface was depressed an average of 2.6 ft, with some areas depressed as much as 6.5 ft. The surveyed volumetric depression totaled 64 percent of the measured trench void space. Neither trench cap bulk density nor permeability was affected by compaction, indicating that the consolidation was primarily subsurface.

The proposed Test Area for Remedial Activities (TARA) Phase 1 involves the dynamic compaction, grouting, and capping of five selected trenches. The area chosen for this demonstration is a hillock of approximately 1 acre in the northeastern part of SWSA 6. This area was selected for several reasons including its hydrologic isolation, the likelihood of its having few containers of liquid hazardous waste, and the ease of monitoring for contaminant release through a suite of perimeter wells (ASG, 1987). Experience gained during TARA Phase 1 will be used in the design of TARA Phase 2, to assess the impacts of dynamic compaction on saturated trenches and on the release of contaminants to groundwater. During compaction, downgradient groundwater will be monitored and, as required, extracted and treated.

2.2.2 The Explosives Detonation Trench

The EDT, which is now backfilled and covered by an ICM cap, was used to detonate explosives and shock-sensitive chemicals, such as acids and oxidizers (e.g., picric acid, phosphorus, ammonium nitrate). The trench is located in the northern portion of SWSA 6 (Figure 2-5) and is approximately 15-ft long by 5-ft wide by 4-ft deep. Wastes were placed in the bottom of the trench and detonated with small plastic charges; debris from the explosions generally remained in the trench. Table 2-1 lists waste known to have been detonated at the EDT (ORNL, 1985). A closure plan for

TABLE 2-1

WASTE ITEMS DETONATED AT THE EXPLOSIVES DETONATION TRENCH

picric acid	aluminum chloride
picryl chloride	aluminum metal
2,4-dinitrophenyl hydrazine	magnesium metal
picramide	phosphorus pentasulfide
phosphorus	methyl acrylate
zinc peroxide	titanium trichloride
nitromethane	potassium azide
2,4-dinitrophenol	phosgene
hydrazine solution	zinc metal
barium peroxide	phthalic anhydride
hydrogen peroxide	cobalt metal
sodium azide	chromium metal
charcoal solution	niobium powder
thionyl chloride	neodymium
ammonium nitrate	zirconium metal

Source: ORNL (1985).

the EDT has been filed in accordance with 40 CFR Section 270.14(b)(13-18), Sections 264.110-115, and Section 264.178 and TN 1200-1-11-.07(5)(a)(13-16) (ORNL, 1985).

2.2.3 The Emergency Waste Basin

The EWB was constructed in 1961-1962 to serve as an emergency holding basin for LLW or process wastes. It was to be used when ORNL was unable to release to WOC. The basin, which encompasses approximately 2 acres and has a potential storage volume of 15 million gallons, was reportedly never used.

2.3 PREVIOUS INVESTIGATIONS

Numerous investigations have been conducted over the past 20 years regarding site physical characteristics and site contamination at SWSA 6. This section briefly describes the scope of a number of these investigations. Selected results are included in Sections 4.0 and 5.0. Complete results are available in the referenced reports.

In the following paragraphs, the general administrative programs under which individual investigations were conducted are described (Section 2.3.1). These are followed by descriptions of specific investigations pertaining to source areas (Section 2.3.2), geology and soils (Section 2.3.3), surface water and sediments (2.3.4), groundwater (Section 2.3.5), and general reviews (Section 2.3.6).

2.3.1 General Programs of Site Investigation

Most previous investigations and studies performed at SWSA 6 have been conducted under one of the following programs:

- o Study of contaminant releases to WOC watershed
- o ETF site characterization

- o SWSA 6 DOE Order 5820.2 site characterization
- o WAG 6 RI site characterization activities
- o WAG 6 RCRA groundwater monitoring
- o Demonstration of potential closure technologies
- o WAG 6 RCRA ICM monitoring
- o Tumulus project environmental monitoring

Some of these investigations focused on WAG 6; others focused on other areas of ORNL, but included all or parts of WAG 6 within their scope. The objectives and general scope of each program are briefly outlined in the following paragraphs.

2.3.1.1 Study of Contaminant Releases to WOC Watershed. In April 1983, a program was initiated at ORNL to: 1) assess radioactive contaminant contributions to the Clinch River from wastes buried in the WOC watershed, and 2) implement appropriate corrective measures. The scope of work included Seepage Trench 7 (in WAG 7) and SWSAs 5 and 6. Site characterization activities conducted in connection with this program are reported in periodic status reports (e.g., Duguid, 1976; Tamura et al., 1980) and are described in subsequent sections.

2.3.1.2 ETF Site Characterization. As part of DOE research and development activities, ORNL designed and constructed an experimental facility to investigate and demonstrate the application of improved engineering techniques to the design of land disposal facilities, specifically shallow land burial of LLW. This facility was located in the western portion of SWSA 6, an area not used for waste disposal. The program had four major objectives: 1) to evaluate cement-based grouts and liners as trench treatments to reduce infiltration, 2) to evaluate certain site characterization techniques, 3) to integrate site characterization with model development, and 4) to develop and validate a model describing site performance. Numerous site

characterization activities were conducted in support of the second objective, and these activities are reported in Davis et al. (1984).

2.3.1.3 DOE Order 5820.2 Site Characterization Activities. When SWSA 6 was opened in 1969, little guidance was provided on site characterization requirements for new LLW disposal sites. In response to the subsequent establishment of such site characterization guidance (DOE Order 5820.2 and NRC 10 CFR Part 61), ORNL compiled existing SWSA 6 site information (Boegly, 1984) and subsequently prepared a characterization plan for SWSA 6 to satisfy outstanding data needs (Boegly et al., 1985). The primary emphasis of this investigation was to collect geologic and hydrologic data necessary to understand the physical and geochemical environment of the SWSA. The approach taken to characterize the disposal environment focused on hydrology, geochemistry, geology, and soils. During the course of these activities, the events described in the following section (2.3.1.4) transpired and resulted in a redirection of the SWSA 6 characterization activities.

2.3.1.4 WAG 6 RI Site Characterization Activities. In May 1986, SWSA 6 was closed to burial operations by DOE pending an investigation of the disposal of RCRA-regulated wastes in the SWSA. It was determined that approximately 25 percent of the landfill area of the site may have been used for the disposal of RCRA-regulated wastes. In April 1986, ORNL revised its RCRA Part A permit application to reflect hazardous wastes disposed in SWSA 6 since 1980. In July 1986, the site was reopened for disposal of LLW only, and SWSA 6 was designated as a RCRA-regulated mixed waste site due to the hazardous wastes disposed at the SWSA between 1980 and May 1986.

A draft RCRA closure plan was subsequently prepared for the site and submitted to the regulatory agencies (IT, 1986). The closure plan specified preparation and implementation of an RI

plan. In December 1986, the draft RI plan was completed (ORNL, 1986). The plan was submitted to the regulatory agencies for review, and ORNL commenced implementation of the plan. Specific investigations conducted under the RI plan and the previous Site Characterization Plan are discussed in subsequent sections.

2.3.1.5 WAG 6 RCRA Groundwater Monitoring. As part of the RCRA 3004(u) assessment of the need for corrective actions at SWMUs, ORNL has installed a series of groundwater quality monitoring wells around the perimeter of SWSA 6 to determine if the site is a source of continuing releases of hazardous constituents. In addition, several wells of similar construction were installed within the SWSA. Wells were sampled quarterly for one year and analyzed for a range of chemical and radiological parameters. Data are presented in Appendix A and summarized in Section 5.0. Well installation is described in Hyde (1987) and Murphy (1988). The RCRA sampling and analysis plan is described in Mortimer and Ebers (1988).

2.3.1.6 Demonstration of Potential Closure Technologies. With the objective of developing techniques applicable to the closure of LLW shallow land burial facilities, ORNL has conducted a number of field trials of potential closure techniques. These trials have included trench dynamic compaction (e.g., Spalding, 1986; Davis et al., 1989) and in-situ grouting of trenches (e.g., Spence, Godsey, and McDaniel, 1987; Spalding, Hyder, and Munro, 1985). Spalding et al. (1989) summarized most of these demonstrations in a single document. For some of these field trials, site characterization data were developed and reported in the field trial documentation. These data generally pertain to the geochemistry of trench waters and surrounding soils and, in some cases, include data pertaining to trench water and soil contaminants. Individual studies that generated environmental data are described in Section 2.3.2.

2.3.1.7 WAG 6 RCRA ICM Monitoring. A RCRA closure plan for SWSA 6 (BNI, 1988a) was submitted to the regulatory agencies and subsequently approved. This closure plan specified installation of a RCRA ICM to begin on November 8, 1988. The ICM involved construction of temporary caps over the RCRA-regulated areas within SWSA 6. The caps are intended to reduce infiltration of surface water into the covered trenches, and thus reduce the probability of migration of contaminants from the capped areas. Because the ICM involved considerable earthwork, post-implementation monitoring is being conducted to determine construction impacts on stream sediment size distributions and contamination of sediments and surface water. Groundwater monitoring is also being performed in the vicinity of the capped areas to aid in assessing the effectiveness of the ICM. The results of this monitoring are presented in a series of monthly monitoring reports (Environmental Consulting Engineers, 1988) and will be summarized in an annual report.

This section has briefly outlined the programs under which many SWSA 6 studies have been conducted. The following sections describe investigations that have yielded site characterization data and are organized according to the following categories/ environmental media: source areas, soils and geology, surface water and sediments, and groundwater.

2.3.1.8 Tumulus Project Environmental Monitoring. The Tumulus Disposal Demonstration Project (TDDP) was initiated as part of continuing efforts to develop better waste management practices for solid LLW. The TDDP was developed and implemented as part of the Low Level Waste Disposal Development and Demonstration (LLWDDD) Program. As this is a demonstration, intensive monitoring and analysis are part of the overall project and will provide the capability of evaluating the total performance of the facility. Yager and Craig (1989) and Yager et al. (1989) summarize, analyze, and evaluate environmental monitoring data collected for the TDDP starting in June 1987. The environmental

data collected include run-off water quality and quantity, groundwater quality and levels, soil sampling and hydrometeorological data. These data are analyzed to demonstrate the environmental performance objectives for the TDDP as part of the overall performance assessment. Comparisons are made between pre-and post-operational data. The data indicate no significant environmental impacts since operations began.

2.3.2 Source Characterization

The following paragraphs describe source information available directly from ORNL's waste management records and the scope of specific environmental investigations yielding additional source characterization data.

2.3.2.1 SWSA 6 Waste Management Records. Waste disposal records have been kept for each shipment of waste to SWSA 6 since the SWSA was opened in 1972. These records are part of the ORNL Solid Waste Disposal Log, a computerized data base documenting each shipment sent to the SWSA. The nature of the data recorded in the data base has evolved through three modifications as described by Boegly et al. (1985) and Davis and Solomon (1987). The three modifications are referred to as MOD 1, MOD 2, and MOD 3.

MOD 1 was employed by ORNL from January 1962 through December 1974. MOD 2 was employed from January 1975 to March 1977. In general, MOD 1 and MOD 2 contain incomplete information on the total radioactivity in waste shipments and no information on chemical (organic or inorganic) wastes.

In March 1977, MOD 3 was adopted in response to the development of a nationwide data retrieval system by the National LLW Management Program. This system, generally known as the Solid Waste Information Management System (SWIMS), required that LLW volumes and activity levels be itemized in eight nuclide

categories: transuranium (TRU), uranium/thorium, fission product, induced activity, tritium, beta-gamma TRU, alpha, and other.

In general, the activities entered into the ORNL Waste Disposal Log are estimates only, made by the waste generator at the time of disposal. The values in the log have not been reduced to account for radioactive decay since disposal.

Information pertaining to excavation, operation, and backfilling of trenches and auger holes is maintained in the SWSA 6 burial ground operator's logbook. Surveyed trench coordinates are maintained by the ORNL Engineering Division.

The data contained in the SWIMS and that maintained by ORNL Engineering Division have been used by ORNL to generate site maps that show trench and auger hole disposal locations and identify the nature of wastes disposed in those locations (e.g., asbestos, biological wastes, and low-activity wastes). These maps and the SWIMS data base serve as the basis for understanding potential radioactive contaminant source areas, which are described in Section 5.0.

2.3.2.2 Summary of the ORNL SWSA 6 Waste Inventory: 1972 through 1986. Davis and Solomon (1987) created three separate data bases by combining information from the ORNL Waste Disposal Log, the WAG 6 operator's logbook, and the ORNL Engineering Division survey records to render SWSA 6 waste management records into a format more appropriate for performing site characterization studies at SWSA 6.

In general, these data bases contain the type of trench/auger hole, the trench/auger hole center coordinates, the opening and closing dates of each trench/auger hole, comments found in the SWSA 6 operators logbook, total trench/auger hole activity, and the activities of radionuclides disposed. In addition, they

computed the activity as of May 21, 1986 for radionuclides with half-lives less than 100 years. Activity due to radioactive daughters of identified radionuclides was not considered in these calculations.

2.3.2.3 Trench Photos and Geologic Descriptions. ORNL (Davis et al., 1986) took photographs and recorded geologic information for 17 trenches opened from July 1984 through September 1985. Information collected includes photos of trench contents and selected trench walls, a brief geologic description of the profile revealed by the excavation, a range of depths of soil cover, average geologic strike of strata, an estimated range of geologic dip of strata, and the presence of water in the trench. This information has aided in the understanding of site geology, which is described in Section 4.0. The photos of typical waste forms will aid in appropriate modeling of contaminant release and in evaluating remediation alternatives during Phase II of the RFI.

2.3.2.4 Environmental Studies of ORNL Waste Disposal Areas. As part of an ongoing ORNL project to characterize contaminants released from ORNL waste burial grounds to the Clinch River (described in Section 2.3.1.1), water samples were collected from 26 trenches within SWSA 6 during 1976 (Tamura et al., 1980). The concentrations of strontium-90, cobalt-60, and cesium-137 were determined for each sample. These data are presented in Section 5.0.

2.3.2.5 Trench Leachate and Groundwater Sampling. With the objective of gathering data with which to develop contaminant source terms for use in modeling future site performance, Solomon et al. (1988) sampled and analyzed leachate from 14 wells located within trenches and water from five groundwater wells within SWSA 6. Leachates were sampled from trenches 8, 41, 92, 135, 163, 219, 260, 257, 288, 315, 391, 405, 417, and 444. Groundwater was sampled from Wells S-11, 647, 648, 649, and 650B.

Sampling occurred between March 1986 and July 1987. Samples were field-analyzed for temperature, acidity, dissolved oxygen, redox potential, conductivity, and alkalinity. In the laboratory, chemical analyses were performed for inductively coupled plasma (ICP) elements, mercury, ammonia, inorganic and total carbon, and major cations and anions. For seven of the trenches and all the wells, analyses were also performed for the EPA Target Compound List (TCL). Radiological analyses included gross alpha and gross beta; specific alpha- and beta-emitting radionuclides (if indicated by gross analysis results); tritium, carbon-14, and technetium-99; and determination of gamma-emitting radionuclides by gamma spectroscopy.

In addition, four of the trenches (41, 92, 257, and 288) were sampled on three separate dates to examine time-variations in radioactive contaminant concentrations and water chemistry. A comparison of trench leachate contaminant concentrations with ORNL waste disposal records indicated no useful correlation between the two. The trench leachate contaminant data are presented in Section 5.0.

2.3.2.6 Trench Bottom Soil, Cap Soil, and Leachate Sampling. As part of studies connected with field scale demonstrations of trench closure techniques, soil samples were collected on July 1, 1988 from the bottom of trenches 2, 3, 4, 5, and 6, and from the cap of Trench 3 (Davis et al., 1989). Samples were screened in the field for gross beta/gamma activity and were analyzed in the ORNL laboratory for cesium-137, cobalt-60, and strontium-90.

Between October 27 and November 20, 1987, during trench void space determination, trench water samples were collected for analyses (Davis et al., 1989). The samples were of waters injected into the trenches during trench void space determination. They were characterized by measuring pH, electrical conductivity, dissolved solids, hardness, alkalinity,

and gross alpha and gross beta activities. These analyses were also performed on a sample of water from the EWB, which served as the source of water employed during the trench void space determinations.

2.3.2.7 Trench Leachate Sampling for Trench 271. In the course of a field demonstration of dynamic compaction on trench 271 within SWSA 6 during 1985 (Spalding, 1986), samples of water being pumped into the trench for the determination of void space and samples of the resulting trench leachate were collected and analyzed for pH, electrical conductivity, dissolved solids, hardness, alkalinity, and gross alpha and beta activity. Samples of groundwater from wells around the trench were collected prior to pumping water into the trench and were analyzed for the same parameters. Radiological results are presented in Section 5.0.

2.3.2.8 Reactor Components Discharged from the High Flux Isotope Reactor (HFIR) and Disposed in SWSA 6. Kelmers and Hightower (1987) completed a study to characterize the potential release rates of radionuclides from HFIR wastes placed in SWSA 6. The study included a review of contributions of HFIR wastes to the radioactive inventory at SWSA 6, a description of HFIR wastes and the placement technique, and geochemical conditions at SWSA 6. This study involved no sampling or analysis but contains detailed descriptions of the HFIR wastes. The information contained in Kelmers and Hightower (1987) will be used, as appropriate, in support of contaminant transport modeling conducted during Phase I, Activity II of the RFI.

2.3.3 Geologic and Soils Investigations

The following paragraphs describe some of the previous investigations that resulted in site soils and geological information. With a few exceptions, only site-specific investigations are described; however, there have been numerous

projects conducted by ORNL that have yielded geologic and soils information for Melton Valley in general.

2.3.3.1 Investigation Prior to Opening of SWSA 6. Prior to the use of SWSA 6 for waste disposal, the site was the subject of a geohydrologic assessment, which was documented by Lomenick and Wyrick (1965). Wells were installed to depths of up to 20 ft during the investigation. Soils and geologic information was collected during drilling, and this information has been considered in the development of the description of site geology, as presented in Section 4.0.

2.3.3.2 ETF (Engineered Test Facility) Geologic and Soils Investigations. The framework for the ETF project is described in Section 3.2.1. ETF soils investigations reported in Davis et al. (1984) included evaluation of radionuclide adsorption properties, soil chemical properties, soil physical properties, and morphology. Radionuclide distribution coefficients were determined in the laboratory for americium-241, strontium-90, cesium-137, cobalt-60, iodine-125, iron-59, and chromium-51.

For soil chemical properties, exchangeable cations were determined by elemental analyses of calcium, magnesium, potassium, and sodium. Exchangeable acidity and cation exchange capacity (CEC), percent base saturation, percent organic matter, pH, and hardness were also determined. Soil physical properties reported include bulk densities and approximate particle size distributions. For the soil morphological descriptions, parameters such as soil color, texture, aggregate structure, and plant root density and penetration were noted.

The investigation of site-specific geology included examination of lithology, structure, and chemical properties of the underlying geologic formation. Information was collected by coring eight boreholes drilled for installation of wells at the ETF. The investigation of lithology included visual

classification of the rock cores, x-ray diffraction of selected core samples to determine clay mineralogy, and geophysical logging of the boreholes. Geophysical logging included natural gamma and neutron attenuation logs. Structure was investigated by observation of trench excavations, evaluation of surface geophysical data, and visual observation of drill samples. The surface geophysical investigation to characterize geology included three surface geophysical methods: shallow electrical resistivity, shallow seismic refraction, and ground penetrating radar (GPR).

The chemical and radionuclide adsorption properties of the saprolite were characterized using samples of cuttings collected during drilling. Radionuclide distribution coefficients, chemical analyses, and physical property determinations were also performed.

The data developed during the course of the ETF investigations have aided the understanding of site geology (described in Section 4.0) and will be employed, as appropriate, to support modeling of contaminant transport during Phase I, Activity II of the RFI.

2.3.3.3 Data Developed During Construction of the 49-Trench Drain. During construction of a French drain for diversion of groundwater in the 49 Trench area in SWSA 6, geologic and soils data were collected from the trench excavation (Davis and Stansfield, 1984). The thickness and nature of surficial soils and the lithology of the consolidated strata were recorded. Fracture density and orientation, folds, and a fault were documented. The geologic and soils data developed during this project have aided the overall understanding of the geology of WAG 6, which is described in Section 4.0.

2.3.3.4 Soil Survey of SWSA 6. Lietzke and Lee (1986) completed a soil survey of SWSA 6. During this survey, soil mapping was

accomplished at a scale of 1:1200 by walking over the entire site, making periodic observation of landforms and soils. As a result, SWSA 6 soils were segregated into nine different map units. For each map unit, a record was made of soil genesis, soil classification, soil color, and pH. This soil classification has supported a better understanding of the surficial geology of WAG 6 (Section 4.0) and may be employed in support of geotechnical design of WAG 6 remedial and closure measures.

2.3.3.5 Soil and Saprolite Characteristics in SWSA 6. In 1987, Ammons et al. (1987) completed an investigation of soil and saprolite characteristics in SWSA 6. The objective was to collect general information regarding the chemical, mineralogical, physical, and engineering properties of soils and saprolite within SWSA 6. Soil and saprolite samples were collected from five soil profiles within the SWSA. Physical analyses included size distribution, Atterberg limits, bulk densities, and specific gravity. Mineralogical analyses included x-ray diffraction and differential scanning calorimetry. Micromorphological analyses included petrographic analysis on thin section samples and examination with a scanning electron microscope. Chemical analyses included soil pH, organic carbon, calcium carbonate equivalent (CCE), exchangeable bases, exchangeable acids, and CEC. As noted for the soil survey conducted by Lietzke and Lee (1986), this investigation supports a better understanding of WAG 6 surficial geology and may be used in support of geotechnical remedial design.

2.3.3.6 Shallow Trench Characterization Study. The general objective of this investigation was to characterize the orientation and density of fracture networks in saprolite in SWSA 6 (Dreier and Beaudoin, 1986). Ten investigation trenches were constructed. Trenches were aligned as close to parallel or perpendicular to geologic strike as possible. Each trench was mapped at a scale of 1:120. All bedding, fracture, fault, and

fault orientation data were recorded and plotted on maps. In addition, fracture densities were measured at 10-ft increments in the trenches. Results of this study have contributed to the current understanding of WAG 6 surficial geology.

2.3.3.7 Other Investigations. Other investigations that resulted in collection of soils and geologic information pertinent to SWSA 6 are briefly described in the following paragraphs. In general, these investigations focused on other topics and yielded only minor soils and geologic data, or were not specific to SWSA 6 but yielded data pertinent to SWSA 6. Results of the investigations described below have been used in Sections 4.0 and 5.0. During Phase I, Activity II of the RFI, data regarding soil physical and chemical characteristics will be used, as appropriate, to support contaminant transport modeling.

Spalding, Hyder, and Munro (1985) describe a field trial of grouting three small test trenches within SWSA 6. As part of the project, measurements of hydraulic conductivity were made in four borings around the three test trenches. In addition, soils encountered during the excavation of the trenches were described. In another remedial action demonstration, Spalding (1986) dynamically compacted Trench 271 within SWSA 6. In conjunction with this project, trench cover soil bulk density and moisture contents were measured. In addition, surface water infiltration rates were measured for the trench cover soils, both before and after dynamic compaction. As part of the TARA project, Davis et al. (1989) collected considerable site characterization data. Trench cover soil bulk density and moisture contents were measured both before and after dynamic compaction. Around the trenches, 39 Standard Penetration Tests (SPTs) were performed. Samples of trench bottom soil were collected from five trenches and screened for radioactivity in the field. The samples were subsequently dried and submitted for determination of cesium-137, cobalt-60, and strontium-90. Of the samples collected, those with the 10 highest readings were analyzed for volatile organic

compounds (VOCs). These selected samples were also analyzed for cesium-137, cobalt-60, and strontium-90.

Considerable site characterization data have been collected for the proposed SWSA 7, located to the east of SWSA 6 within Melton Valley. These site characterization data, while not specific to SWSA 6, are useful supplementary information because SWSA 7 is situated on the Conasauga Group (as is SWSA 6). Lomenick et al. (1983) described an initial evaluation of the ORNL area for potential SWSA sites. This investigation primarily involved reviewing existing information and involved only minor amounts of field work. The investigation focused on Melton Valley, underlain by the Conasauga Group, and contains descriptions of Melton Valley soils. Rothschild et al. (1984a) provided a soils characterization of the proposed SWSA 7 site. The study included a soil survey, determination of mineralogy, and an assessment of soil hydraulic properties, radionuclide adsorption properties, chemical properties, engineering properties, and erosion potential. Rothschild et al. (1984b) presents the results of a geohydrologic investigation of the proposed SWSA 7, which addresses in some detail site geology, surface water, and groundwater.

As reported in Davis et al. (1987) in the second half of 1986, drilling was initiated on a deep corehole south of White Oak Lake. This hole, designated as WOL-1, was drilled to sample lithologies of units that immediately underlie SWSA 6 and for hydrofracture investigations. Cores were retrieved and visually logged in detail. The corehole was then logged with a variety of geophysical instruments to determine lithology. In addition to lithologic logging, the core was logged to record structural fabrics and fracture densities. This investigation provided information on the bedrock stratigraphy of the Conasauga Group underlying SWSA 6.

2.3.4 Surface Water and Sediment Investigations

The following paragraphs describe previous site-specific surface water and sediment investigations for SWSA 6.

2.3.4.1 ETF Surface Water Investigations. As part of a study to assess the performance of selected site characterization techniques, a test site was established in the western portion of SWSA 6 (Davis et al., 1984). Investigation of the ETF included surface water data collection. The characterization of surface water hydrology included both an evaluation of the quality and the quantity of surface water flow. Parshall flumes equipped with automated flowmeters and flow proportional water samplers were placed in both channels draining the ETF site. Surface water sampling included the collection of a mixture of proportional and grab samples from both streams over an extended period of time. In addition to surface water flow measurements and sampling, an investigation of surface water infiltration rates was completed. This involved the installation of a group of six infiltrometers around the ETF site. Surface water flow data were collected over a 30-month period extending from October 1980 to March 1983. Water quality and radionuclide analyses were performed once a quarter to determine baseline conditions at the site. In addition, weekly grab samples were collected and monitored for pH and electrical conductivity. Radionuclide analyses have been considered in assessing the nature and extent of contamination at WAG 6.

2.3.4.2 49 Trench Area French Drain Sampling. Davis and Marshall (1988) reported on the effectiveness of the 49 Trench area drain, which was installed to suppress the groundwater table in that area. Surface water samples were collected from the outlets to the north and east legs of the drain and from the 49 Trench area west creek seep. Samples were analyzed for tritium, strontium-90, cesium-137, and cobalt-60. These data are

considered in the assessment of the nature and extent of contamination in Section 5.0.

2.3.4.3 USGS Precipitation Data Collection. Webster et al (1982) summarize precipitation data for January 1976 through December 1980 for two stations; one each in SWSA 5 and SWSa 6. Daily, monthly, and annual values are reported.

2.3.4.4 USGS Hydrologic Interpretation of Melton Valley. Webster and Bradley (1988) have reviewed existing geologic and hydrologic data pertaining to SWSAs 4,5, and 6, all located in Melton Valley. Based on this review, they drew conclusions regarding the general hydrology of Melton Valley and implication for contaminant transport. Surface water, regolith, and bedrock hydrology are discussed individually. The authors concluded that the two primary modes of contaminant transport are by dissolution in circulating ground-water and the overflow of trench leachate and subsequent flow across the ground surface.

2.3.4.5 Site Characterization Activities - Surface Water. As part of SWSA 6 site characterization efforts in support of closure planning, a review and data collection were performed to compile data through July 1986 for water balance studies. Precipitation data (1980 through 1986) and streamflow data for the three major drainages in SWSA 6 were collected (June 1985 to July 1986). These data will be employed during contaminant transport analyses to be conducted during Phase II of the RFI.

2.3.4.6 1981 WOC and Tributaries Streambed Contaminant Survey. Cerling and Spalding (1981) completed a comprehensive assessment of strontium-90, cobalt-60, and cesium-137 concentrations in streambed gravel from contaminated drainages in WOC. In addition to the WOC main channel and the major tributaries, several samples were collected from the minor tributaries in SWSA 6. Radionuclide distribution coefficients were also

determined. Radionuclide concentrations in WAG 6 are discussed in Section 5.0.

2.3.4.7 Investigation of Bedload Transport of Contaminated Gravel. During this investigation of contamination within the WOC drainage, four locations were sampled within SWSA 6. Samples were analyzed for strontium-90, cobalt-60, and cesium-137 (Cerling and Huff, 1985). A sample from one location within the SWSA was analyzed for selected metals, including copper, potassium, zinc, manganese, and iron. Radionuclide concentrations in WAG 6 are discussed in Section 5.0.

2.3.4.8 Toxicity Tests on Water from Streams Near SWSA 6. Samples representative of both wet and dry seasons were collected from a stream at the east side and a stream on the west side of SWSA 6 (Stewart, 1989). A bioassay was performed on the water samples to assess toxicity. Aside from the "wet weather" sample collected from the stream on the west side of SWSA 6, the water samples did not show evidence of toxicity.

2.3.4.9 Other Investigations. Surface water quality monitoring for physical parameters and selected radionuclides has been performed as part of the ICM environmental monitoring. This data is discussed in Section 5.0 and Appendix B.

Though not specific to SWSA 6, the hydrological characterization and interpretation performed as part of the geohydrological investigation of the proposed SWSA 7 may provide supplementary information of value to SWSA 6. The hydrological characterization of SWSA 7 included flow measurements and a computed water balance (Rothschild et al., 1984b).

2.3.5 Groundwater Investigations

The following paragraphs describe previous groundwater investigations and reviews that are either WAG 6 specific or are of general relevance to the site.

2.3.5.1 Preoperational Geohydrologic Evaluation of SWSA 6. Before SWSA 6 was selected for waste disposal operations, Lomenick and Wyrick (1965) conducted a geohydrologic evaluation of the site. Groundwater elevations were collected by installing a series of wells to depths of up to 20 ft, and taking measurements of the water level in these wells periodically during October 1964 to July 1965. Analysis of the results and recommendations regarding appropriate practices for shallow land burial are presented in the report.

2.3.5.2 USGS Hydrologic Data Collection. Webster et al (1980) summarize data for the period 1975 to 1979 for approximately 100 wells installed at SWSA 6. The data includes an inventory of wells, measurements of water levels, well hydrographs, and a map showing the location of the wells. Webster et al (1982) summarize precipitation data for January 1976 through December 1980 for two stations; one each in SWSA 5 and SWSA 6. Daily, monthly, and annual values are reported.

2.3.5.3 1985 Scoping Survey of Contaminants. Taylor and Doyle (1985) describe a scoping survey of contaminants in selected ORNL waste disposal areas. SWSA 6 wells sampled during the survey included Wells 272, 279, 305, 371, 380, and 382. The samples were analyzed for metals and radioisotopes (i.e., strontium-90, cobalt-60, and cesium-137).

2.3.5.4 ETF Groundwater Investigations. The framework for the ETF studies is described in Section 3.2.1. The ETF site characterization program included considerable efforts to evaluate aquifer characteristics, water table fluctuations and the groundwater flow system, and water chemistry (Davis et al., 1984). The investigation of aquifer characteristics included tracer tests, pumping tests, and a series of slug tests. Water levels were continuously monitored in 15 wells located on the ETF site, and approximately 30 months of the data were recorded.

Groundwater chemistry was evaluated by collecting monthly groundwater samples from 12 wells. All samples were analyzed for major cations and anions, as well as trace metals and radionuclides. No samples were analyzed for organics. Aquifer characteristics determined in this study are included in Section 4.0. These data and groundwater chemistry data will be employed, as appropriate, in contaminant transport modeling during Phase I, Activity II of the RFI.

2.3.5.5 Hydraulic Head Measuring Station (HHMS) Program. ORNL initiated the HHMS program with three objectives: 1) to characterize hydraulic head levels in and near ORNL waste management areas, 2) to characterize Melton Valley geology, and 3) to determine groundwater quality at the respective locations. The program involved the installation of 11 well clusters, each consisting of a shallow well (approximately 80 ft deep), an intermediate well (approximately 200 ft deep) and a deep well (approximately 400 ft deep). Hydrologic testing and geophysical logging were performed on selected boreholes during well installation. In addition, water samples were collected and analyzed to assess groundwater geochemistry. A particular objective of the HHMS program is to evaluate the transition between the upper aquifer and the lower aquifer. A summary of HHMS data and results are presented by Dreier and Toran (1989). This work has contributed to the current understanding of hydrogeologic systems underlying SWSA 6.

2.3.5.6 Shallow Constant Head Tracer Tests. As part of the activities specified in ORNL's draft SWSA 6 RI plan (ORNL, 1986), several constant head tracer tests were conducted in the fall of 1986 and 1987 during similar hydrologic conditions (Davis et al., 1987). The test configuration consisted of a central injection hole and six boreholes arranged around the injection hole each of which contained two piezometers, one deep and one shallow. Water with a tracer was injected in the central hole,

and water levels and the presence of tracer were monitored in the piezometers. This work is summarized by Davis et al. (1987).

2.3.5.7 TARA Groundwater Investigations. The TARA project involved the installation of 13 PVC groundwater wells. Water level data sufficient to construct hydrographs for each well from the period April 1987 to August 1988 are presented in this report. Response of monitoring wells to trench water pumping tests conducted in July and October 1987 is included on the hydrographs.

Groundwater sampling was conducted between November 18 and 23, 1987, and included collection of samples from each of the 15 wells. Field measurements included temperature, pH, dissolved oxygen, and electrical conductivity. In addition, samples were submitted for laboratory analysis for elements using ICP analysis, hardness, alkalinity, total organic carbon (TOC), total dissolved solids (TDS), 91 semivolatile organic compounds (SVOCs), radionuclides, mercury, potassium, and major anions. To determine how groundwater quality changed with time, additional samples were collected from the 15 wells in May 1987, November 1987, June 1988, and August 1988. These samples were analyzed for pH, electrical conductivity, hardness, alkalinity, dissolved solids, tritium, and gross beta and gross alpha radioactivity. Methods, procedures, and data are presented in Davis et al. (1989). These data were considered in the assessment of the nature and extent of contamination in WAG 6.

2.3.5.8 Piezometer Well Program. Under the ORNL piezometer well installation program, 21 piezometers have been installed in SWSA 6. As described by Mortimore (1987a; 1987b), during installation, cuttings were monitored for radioactivity, and samples of water and soil cuttings were submitted for laboratory radiological and chemical analyses. Hydrologic testing was performed on the piezometers and water level data have been recorded.

2.3.5.9 RCRA Monitoring Well Program. As described in Section 2.3.1.5, ORNL has undertaken a compliance groundwater monitoring program at WAG 6 (Mortimer and Ebers, 1988). To date, four quarters of groundwater data have been obtained. These data are presented in Technical Memorandum 06-07, "Validation of ORNL Groundwater Data." Also, hydraulic conductivity testing has been conducted on these wells, and water level data have been recorded.

2.3.5.10 Other Investigations. Spalding, Hyder, and Munro (1985) describe a field trial of grouting three small test trenches within SWSA 6. As part of the project, measurements of hydraulic conductivity in the unperturbed soil formation in four borings around the three test trenches were performed.

Moore (1988a and 1988b) describes the occurrence, size, depth, spatial frequency, and hydrologic significance of cavities in the fractured rock aquifers. The analysis in this report is based upon numerous observation wells and borings drilled in the ORNL area since 1949. The review includes an analysis of fractures within the Conasauga Group, which underlies SWSA 6.

Moore (1988c) recently completed a comprehensive analysis of existing groundwater data in the ORNL area and developed concepts regarding groundwater occurrence and flow. While specific local flow systems and local problems in ORNL SWSAs (e.g., such as SWSA 6) are not discussed, the results contribute to the overall understanding of groundwater flow at SWSA 6.

Groundwater quality and water table data have been collected in conjunction with Tumulus environmental monitoring (Yager and Craig, 1989; Yager et al, 1989) and water table elevation data have been collected in conjunction with ICM environmental monitoring. As previously noted, Tumulus environmental monitoring data indicates no significant contamination. Water

table data from both the Tumulus and ICM programs contributes to the understanding of local hydrologic conditions in WAG 6.

Off-site field investigations that may provide supplemental information of value for characterizing SWSA 6 hydrogeology include pumping tests performed in 1971 and 1972 by McMaster (1971, 1972). In addition, a hydrogeologic investigation was performed for the proposed SWSA 7 located in Melton Valley to the east of SWSA 6 (Rothschild et al., 1984). Because the proposed SWSA 7 has similar topography and is located over the same geologic formation (Conasauga Group) and in the same hydrogeologic setting, this site characterization data may be of use in understanding the hydrogeology of SWSA 6.

2.3.6 General Reviews

A number of studies have been completed that synthesized and/or interpreted previous information regarding the geology, surface water hydrology, and hydrogeology of the ORNL area, including SWSA 6. These include Lomenick and Wyrick (1965), Webster (1976), Duguid et al. (1977), Grizzard (1986), and Moore (1988a; 1988b). In general, these studies did not involve a great amount of site characterization pertinent to SWSA 6. However, the interpretations made form part of the progression of understanding SWSA 6 hydrogeology.

3.0 SITE INVESTIGATION

Summaries of the objectives and procedures for the various Phase 1, Activity 1 RFI activities conducted at WAG 6 are presented below. These activities include: review of RFI analytical data quality, RFI well evaluation, soil gas and well-headspace surveys, surface radiological investigation, surface water investigation, geophysical electromagnetic survey, review of ORNL groundwater data quality, monitoring of well installation, groundwater investigation, biohazard investigation, management of RFI-derived waste, and soil investigation.

Details of each Phase 1, Activity 1 RFI task and complete data summaries are included in the technical memorandums listed in Table 3-1 and included in Appendix A of this report.

3.1 DATA QUALITY REVIEW (TECHNICAL MEMORANDUM 06-01)

All Phase 1, Activity 1 RFI analytical results were reviewed to determine if the intended data quality objectives (DQOs) were met. Three levels of data review were used, depending on the level of quality control appropriate to different DQOs.

Level III data included analysis for Target Compound List (TCL) organics, TCL inorganics, and radioactive constituents for selected samples. Data packages met EPA Contract Laboratory Program (CLP) requirements for deliverables and quality control (QC) ("CLP" or "CLP-like" data packages). This includes analytical data, QC summary forms, raw data, and instrument printouts. For Level III, which was the most rigorous level, all sample and QC results (including raw data) were reviewed for precision, accuracy, representativeness, comparability, and completeness (PARCC).

Level II data included TCL organics, TCL inorganics, major ions, and conventional water quality parameters including biochemical

TABLE 3-1

RFI TECHNICAL MEMORANDUMS

Technical Memorandum	Title
06-01	RI/FS Data Quality Review
06-02	RFI Well Evaluation
06-03	Soil-Gas Survey (Phase 1, Activity 1)
06-04	Surface Radiological Investigation (Phase 1, Activity 1)
06-05	Surface Water Investigation (Phase 1, Activity 1)
06-06	Electromagnetic (EM) Survey
06-07	Validation of ORNL Groundwater Data
06-08	Monitoring Well Installation (Phase 1, Activity 1)
06-09	Groundwater Investigation (Phase 1, Activity 1)
06-10	Biohazard Investigation (Phase 1, Activity 1)
06-11	Waste Management (Phase 1, Activity 1)
06-12	Soil Investigation (Phase 1, Activity 1)

oxygen demand (BOD), chemical oxygen demand (COD), and fecal coliform. Data packages included analytical data and summaries of QC results. Level II review was similar to Level III, except raw data were not reviewed.

Level I data included the RCRA waste classification analyses (EP toxicity, reactivity, corrosivity, and ignitability), ICP scan for metals, TOC, total organic halides (TOX), and radioactive constituent analyses. For Level I, the sample results were reviewed for completeness, comparability (of analytical method and concentration units), and representativeness of the data. In addition, all data were reviewed for contract compliance. Sample results were qualified (flagged) by both the analytical laboratory and the data reviewer to indicate data that may have a reduced level of data quality due to problems with the field and/or analytical techniques. Definitions of the qualifiers are given in this technical memorandum.

3.2 EXISTING WELL INVESTIGATION (TECHNICAL MEMORANDUM 06-02)

The existing well investigation consisted of a field reconnaissance to evaluate well suitability for monitoring water levels and water quality sampling. Existing wells included 30 water quality monitoring wells, 25 piezometers, and other selected wells in, or immediately adjacent to, WAG 6.

Field reconnaissance included a visual inspection of the wells, measurements of well depth and water depth, and confirmation of well construction details.

3.3 SOIL GAS INVESTIGATION (TECHNICAL MEMORANDUM 06-03)

Soil gas investigations were conducted to identify the presence of VOCs around the perimeter of selected trench areas in SWSA 6 and used with other nondestructive surveys to identify potential

VOC contaminant plumes, locate sampling points, and determine areas in need of more detailed investigation.

Phase 1 soil gas sampling was conducted in three separate phases. The first phase consisted of collecting and screening 84 soil and well gas samples (headspace) with field analytical instruments. Areas with elevated VOC concentrations were resampled during the second phase and analyzed with a portable gas chromatograph (GC). In general, sample depths ranged from 4 to 9 ft. During the third phase, non-intrusive surface organic sampling devices were placed, retrieved, and analyzed by Quadrel Services, Inc.

3.4 SURFACE RADIOLOGICAL INVESTIGATION (TECHNICAL MEMORANDUM 06-04)

A radiation walkover survey was conducted to provide a quick look at surface radiation levels for the purpose of defining site-specific health and safety practices. Additionally, the information was used to characterize the site surface radioactive contamination. The survey consisted of a surface scan and discrete measurements made at defined locations. The purpose of this survey was to aid in delineating near-surface source areas and to provide a first estimate of relative, near-surface environmental contamination levels at the site. Approximately 74 percent of WAG 6 (or 20 hectares) was covered by the survey with the remainder of the site being inaccessible due to dense undergrowth or active waste disposal. Four types of measurements were made: a continuous near-surface gamma radiation survey made from within 15 cm of the land surface, fixed-position gamma measurements and made at a distance of 30 cm above grade, total beta-gamma radiation level measurements made in contact with the local surface, and gamma radiation exposure rate obtained at a height of 1 m above the local surface.

3.5 SURFACE WATER INVESTIGATION (TECHNICAL MEMORANDUM 06-05)

The surface water from 16 locations on intermittent streams and at seeps in WAG 6 was sampled in February, April, and May 1989. The three primary objectives of the program were to: 1) provide data to help define the extent of contamination of surface waters in WAG 6, 2) provide data to aid in the definition of contaminant migration pathways, and 3) provide data to support development of remedial action alternatives.

This report contains the results from three surface water sampling events as follows:

- o February 1989 - Base flow during the high groundwater level period prior to installation of the ICM cap
- o April 1989 - Base flow during high groundwater level, after installation of the ICM cap
- o May 1989 - Storm event flow during high groundwater level

Water in the EWB was also collected and analyzed in conjunction with the surface water sampling events. A total of 31 samples were collected and analyzed for TCL organics, TCL inorganics, radioactive constituents, anions, TDS, sulfide, alkalinity, COD, TOC, TKN, BOD, and fecal coliform.

Sampling during the low groundwater level period, both baseflow and stormflow events, occurred in the fall of 1989. The results from these sample events will be presented in the WAG 6 RFI Report.

3.6 ELECTROMAGNETIC (EM) SURVEY (TECHNICAL MEMORANDUM 06-06)

An EM terrain conductivity survey was conducted at WAG 6 in November 1988. The specific objectives of the survey were to:

- o Aid in the identification of potential contaminant plumes, and
- o Aid in the location of future groundwater wells and test borings.

Twenty-three survey lines, oriented east-west on the ORNL grid system, were spaced 100 ft apart to cover the WAG 6 area inside the intruder fence. Data were collected at 10-ft intervals along the lines with the data point being the midpoint between the transmitter and receiver. Interpretation of the EM survey data was based on general conductivity values and location of any conductivity anomalies.

3.7 VALIDATION OF EXISTING ORNL GROUNDWATER DATA (TECHNICAL MEMORANDUM 06-07)

The analytical methods and QC procedures applied by ORNL for the analysis of SWSA 6 groundwater samples and the available documentation were reviewed in February 1989 to determine whether the existing groundwater data generated by ORNL meet the DQOs established for the ORNL RI/FS project.

The existing ORNL groundwater data are derived from four sampling rounds (June through September 1988; October through December 1988; January through March 1989; and April through June 1989) at 8 site characterization wells, 15 perimeter wells, and 7 upgradient wells. All samples were analyzed for organics, inorganics, and radiologic constituents.

For all parameters, the level of QC applied was equivalent to, or higher than, the level of QC required by the project for the analysis of WAG 6 samples. The methods used and the available

documentation were consistent with the requirements established for WAG 6 work.

3.8 MONITORING WELL INSTALLATION AND DEVELOPMENT (TECHNICAL MEMORANDUM 06-08)

Nine monitoring wells were installed at selected locations based on information obtained during the subsurface soil sampling and in areas where data gaps were identified from the evaluation of existing wells.

Three of the nine monitoring wells installed were installed as stormflow zone wells, which were screened above the normal range of the water table and below the influence of overland flow. The other six wells were installed as shallow groundwater monitoring wells. Three of these wells may also be influenced by stormflow due to the shallowness of the water table.

3.9 GROUNDWATER INVESTIGATION (TECHNICAL MEMORANDUM 06-09)

The general objectives of the groundwater investigation as conducted in the Phase 1 RFI were to:

- o characterize the movement of groundwater in the area of WAG 6, including the stormflow zone;
- o characterize groundwater quality in the vicinity of WAG 6 and to determine the presence of possible contaminant plumes;
- o determine interactions between surface water (e.g., in seeps, streams, and impoundments) and groundwater; and
- o addressing the above, to determine the need for, and location of, additional site investigation sampling.

Sampling and analysis of groundwater was conducted to investigate the types and concentrations of contaminants currently present in the groundwater and to assess the potential for migration of

contaminants from WAG 6 using flow directions and rates, groundwater geochemistry, and the amount and character of contaminants found.

All groundwater samples were analyzed for TCL organics, TCL inorganics, and radioactive constituents. The nonstorm event samples were also analyzed for fecal coliform, anions (iodide, bromide, fluoride, chloride, nitrate, phosphate and sulfate), TOC, TOX, TKN, COD, BOD, and TDS.

Water level measurements were made in the wells periodically, usually in conjunction with sampling events, to obtain information used in assessing flow direction at the site and in investigating the relationship between groundwater, surface water, and precipitation.

3.10 BIOHAZARD INVESTIGATION (TECHNICAL MEMORANDUM 06-10)

A biohazard investigation was conducted to determine if the microbiological content of the soils, surface water, and groundwater at WAG 6 is of normal character. Samples were analyzed primarily for bacterial content.

Seventeen soil sampling locations were sampled at a depth up to 1 m. All samples were taken downgradient of the biological waste trench areas. A total of 44 water samples were taken in two phases; groundwater samples were taken from the existing RCRA monitoring wells (the well number 800 series), and surface water samples were taken at the gauging stations as they existed in August and November 1988 and at the White Oak Lake control structure.

3.11 WASTE MANAGEMENT (TECHNICAL MEMORANDUM 06-11)

This technical memorandum summarizes types, segregation and classification techniques, packaging, and disposition of wastes generated during the WAG 6 RFI.

Several types of wastes were generated. Whenever possible, wastes were segregated at the point of generation. Other materials were segregated according to their form and field screening results.

With the exception of spent personal protective equipment (PPE), which was disposed as suspect LLW, all waste materials were composite sampled and analyzed for the four RCRA waste characteristics (EP toxicity, corrosivity, ignitability, and reactivity) and radioactivity. Wastes not exhibiting any of the four RCRA hazardous waste characteristics were classified as suspect LLW. All wastes were turned over to ORNL Waste Operations for disposal.

3.12 SOIL INVESTIGATION (TECHNICAL MEMORANDUM 06-12)

The three primary objectives of the soil investigation were to:

- o Provide data to help define the extent of soil contamination in WAG 6
- o Provide data to aid in the definition of contaminant migration pathways
- o Provide soils engineering data to support development of remedial action alternatives

A total of 53 borings were drilled and sampled continuously to auger refusal between December 1988 and January 1989. Borings ranged in depth from 5.4 ft to 51.2 ft. As samples were collected, they were surveyed for chemical and radiological contamination using field instruments. Based on the results of the field screening, a total of 63 samples were collected and

submitted for analysis of TCL organics, TCL inorganics, and radioactive constituents.

Soil borings were placed around the perimeters of the waste disposal areas. Trenches and auger holes themselves were not sampled for two reasons: the difficulty in characterizing heterogeneous waste materials and the hazards presented by drilling into unknown waste materials.

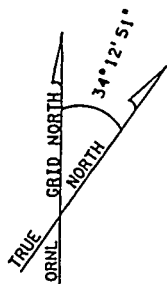
4.0 PHYSICAL CHARACTERISTICS

4.1 TOPOGRAPHY

WAG 6 is located in the irregularly dissected terrain of Melton Valley between Haw Ridge to the northwest and Copper Ridge to the southeast. The present topography reflects a long history of episodic erosion processes. Many valleys of this area are characterized by a high drainage density (Webster and Bradley, 1988). In Melton Valley, numerous short tributaries to the principal streams occur at intervals seldom greater than 2000 feet. Because of drainage density and burial ground size, drainages are included within each burial ground and one or more drainages provide a natural boundary to each site. Davis et al. (1987) note that drainage paths tend to develop in areas of close joint spacing or relatively more fracturing, or in areas reflecting drainage networks of earlier erosion cycles.

Figure 4-1 shows that within WAG 6 there are four principal surface water drainages (FA, FB, DA, and DB) forming a gently undulating topography. Almost all of the WAG 6 land surface drains southeastwardly toward White Oak Lake (WOL), or the adjacent marshy area. Two drainage paths flow northeastwardly. One flows through the EWB and both consequently flow southward to an unnamed tributary which ultimately drains to the marshy area (which defines the approximate high-water level of WOL).

Ground surface elevations range from about 750 ft adjacent to White Oak Lake at the southern boundary and eastern perimeter of the site to greater than 850 ft in the north near the main entrance and the southwest corner. Slopes within WAG 6 are typically between 2 and 12 percent, though locally they may be flatter or steeper. The greatest irregularity of terrain and steepest slopes occur in the northern and northeastern part of the site adjacent to the SWSA 6 access road and near the eastern perimeter road.



N 17500

N 17000

N 16500

N 16000

N 15500

E 23000

E 23500

E 24000

SWSA 6
SWAJ 6.1

TUMULUS WASTE
STORAGE PAD

HWY 65

WHITE OAK LAKE

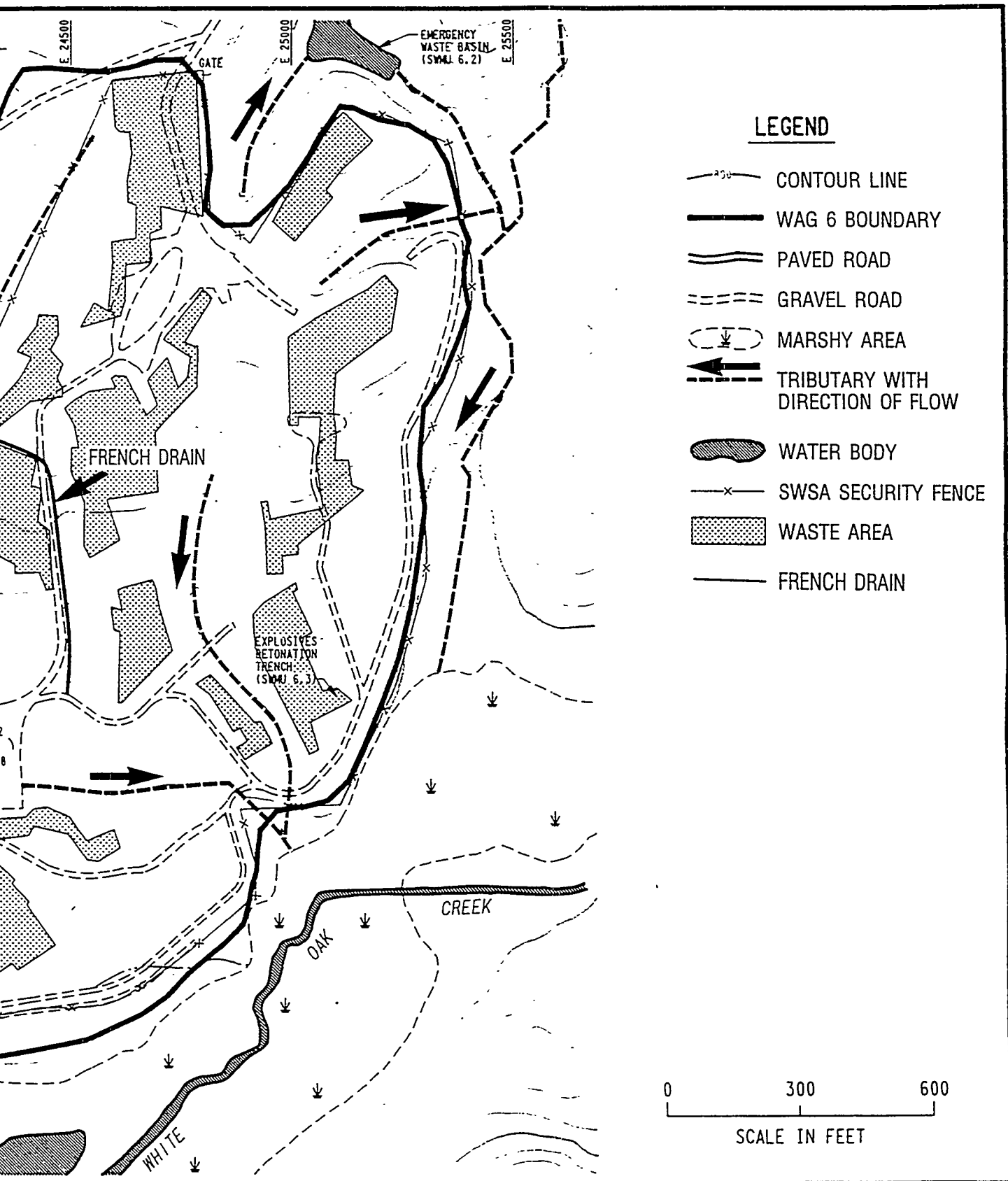


FIGURE 4-1
TOPOGRAPHY AND DRAINAGE PATTERNS
AT WAG 6 AND ADJACENT AREAS

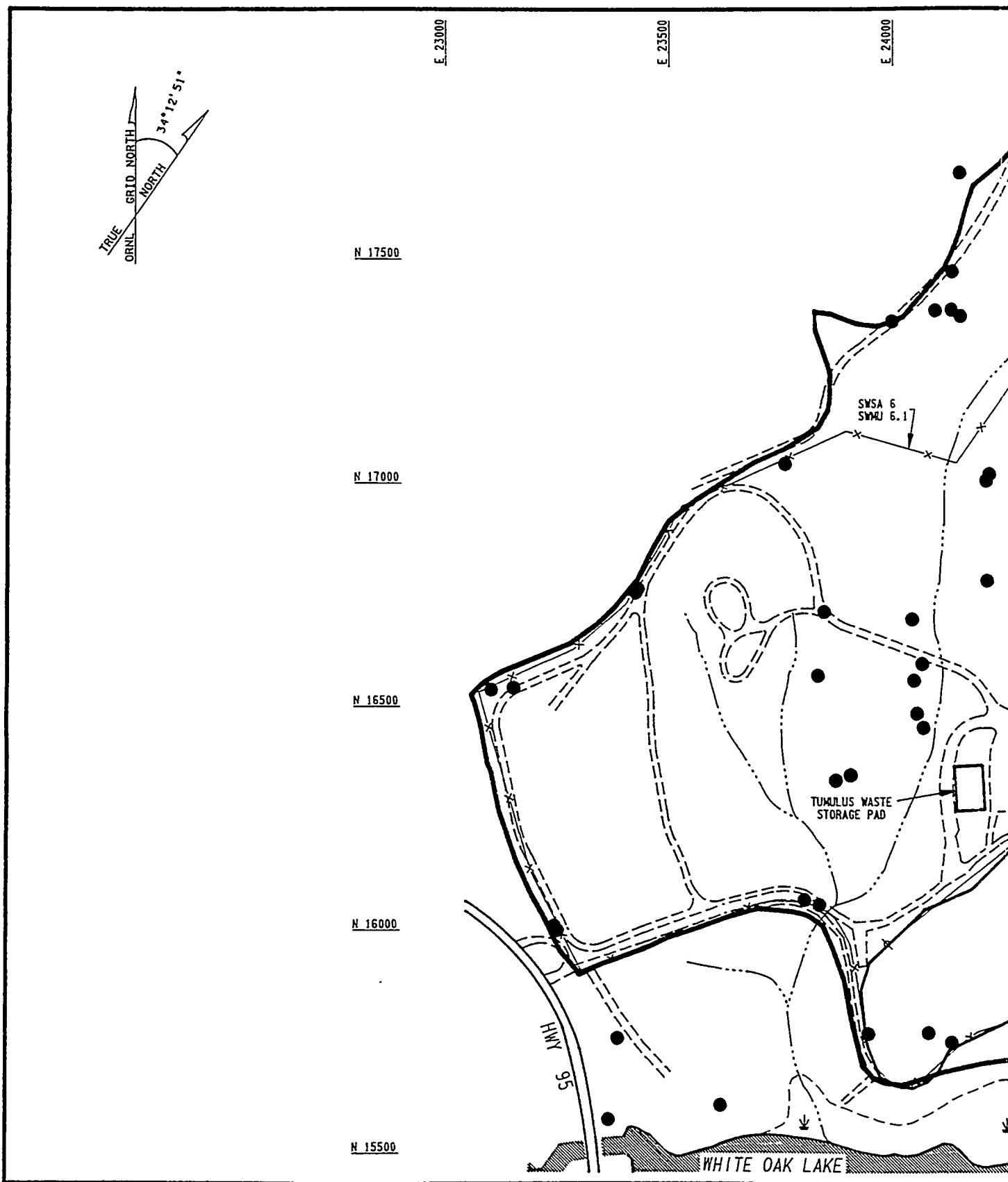
Modification of the land surface for trench disposal has not significantly altered the original surface drainage or slope configuration. However, Davis et al. (1987) reported that, in some areas, thin soils were stripped from trenched areas and pushed into nearby drainages. Prior to use as a disposal site, the WAG 6 area was heavily wooded. Stands of trees remained within the principal drainage paths until the Interim Corrective Measures (ICM) capping work required the removal of trees in the eastern drainage paths. This work was completed in May 1989.

4.2 SURFACE FEATURES

The surface features present at WAG 6 are shown in Figure 4-2. The main surface features of WAG 6 include: three SWMUs as described in Section 2.1, a series of interconnected unpaved roads, two permanent buildings, power and telephone lines, a tumulus pad with stacked concrete vaults, two weather stations, and numerous wells. Except for the EWB located just north of SWSA 6, the entire area is enclosed by an 8-ft high chain link fence topped with barbed wire. Various equipment, including bull dozers, backhoes, graders, forklifts, and trucks, are commonly on site. Concrete vaults used to store and bury waste are also on site but are moved frequently. Six large areas in SWSA 6 were capped with a high-density polyethylene geomembrane (HDPE) to reduce the infiltration of precipitation as part of the ICM project. These areas are roped off. Other than where roads and buildings exist, WAG 6 is covered by either stands of trees or fields of grass and weeds. The grassy areas are mowed during the growing season. Numerous natural and man-made drainages transect the site. Some of these drainages are rip rap lined. Culverts have been installed where drainages cross the roads.

4.3 GEOLOGY

WAG 6 is located in Melton Valley and is underlain by strata of the middle to late Cambrian Conasauga Group in the Copper Creek



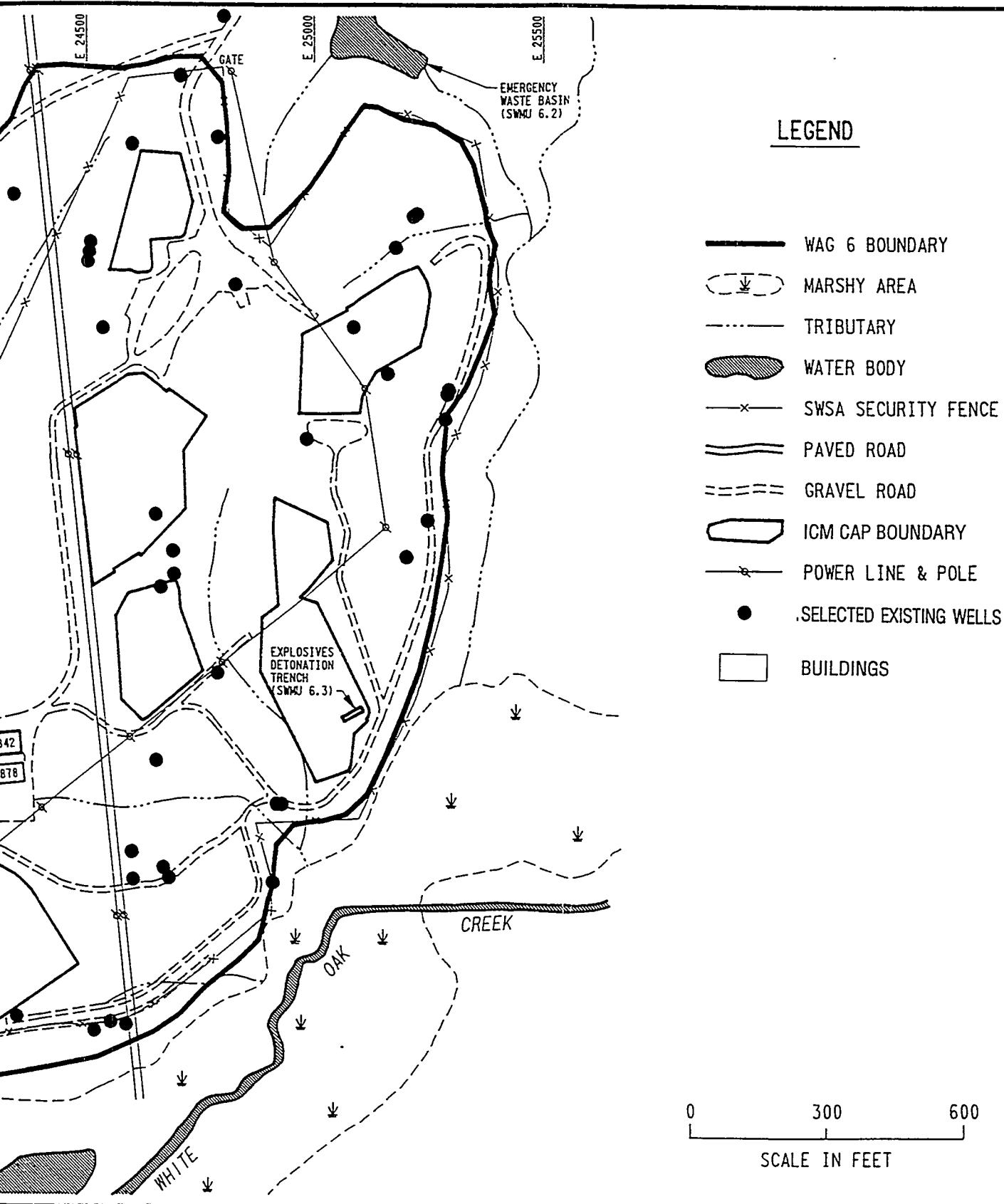
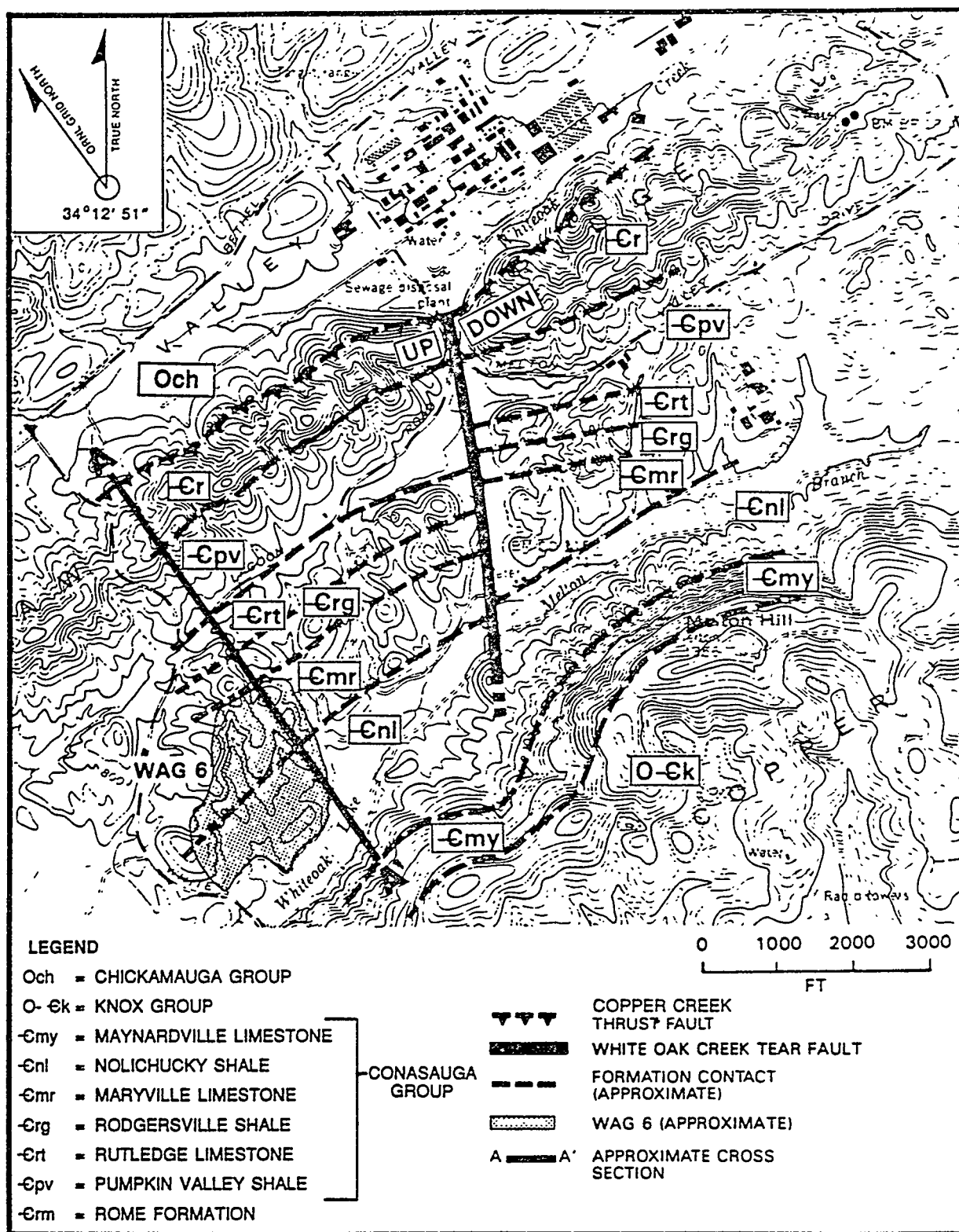


FIGURE 4-2
WAG 6 SURFACE FEATURES

Thrust Block. This section summarizes the findings of selected studies that have made significant contributions to the understanding of the bedrock geology of the Copper Creek Thrust Block and Melton Valley. Although the studies were not all performed in WAG 6, their findings may be applied to the interpretation of site-specific data collected at WAG 6. In Melton Valley, the Conasauga Group is approximately 1,880 ft thick. It is lithologically heterogeneous, consisting of alternating beds of siltstones, silty limestones, calcareous shales, and mudstones, and is structurally complex. The primary structural feature is the Copper Creek Thrust Fault, which is exposed on the north side of Haw Ridge. The Conasauga Group and the underlying Rome Formation constitute the lowermost stratigraphic interval of the Copper Creek thrust sheet. The Copper Creek Thrust sheet is believed to be further segmented by a series of tear faults oriented approximately perpendicular to the leading edge of the sheet thrust and consequently, perpendicular to the bedrock strike. Other structural features of the Conasauga Group include localized folding, bedding plane and vertical fractures, and joint sets. Solution features have also been observed. Webster and Bradley (1988) indicate that "solution cavities of small cross-sectional area have developed in some limestone beds, but no evidence was obtained to demonstrate that an integrated cavity system has developed."

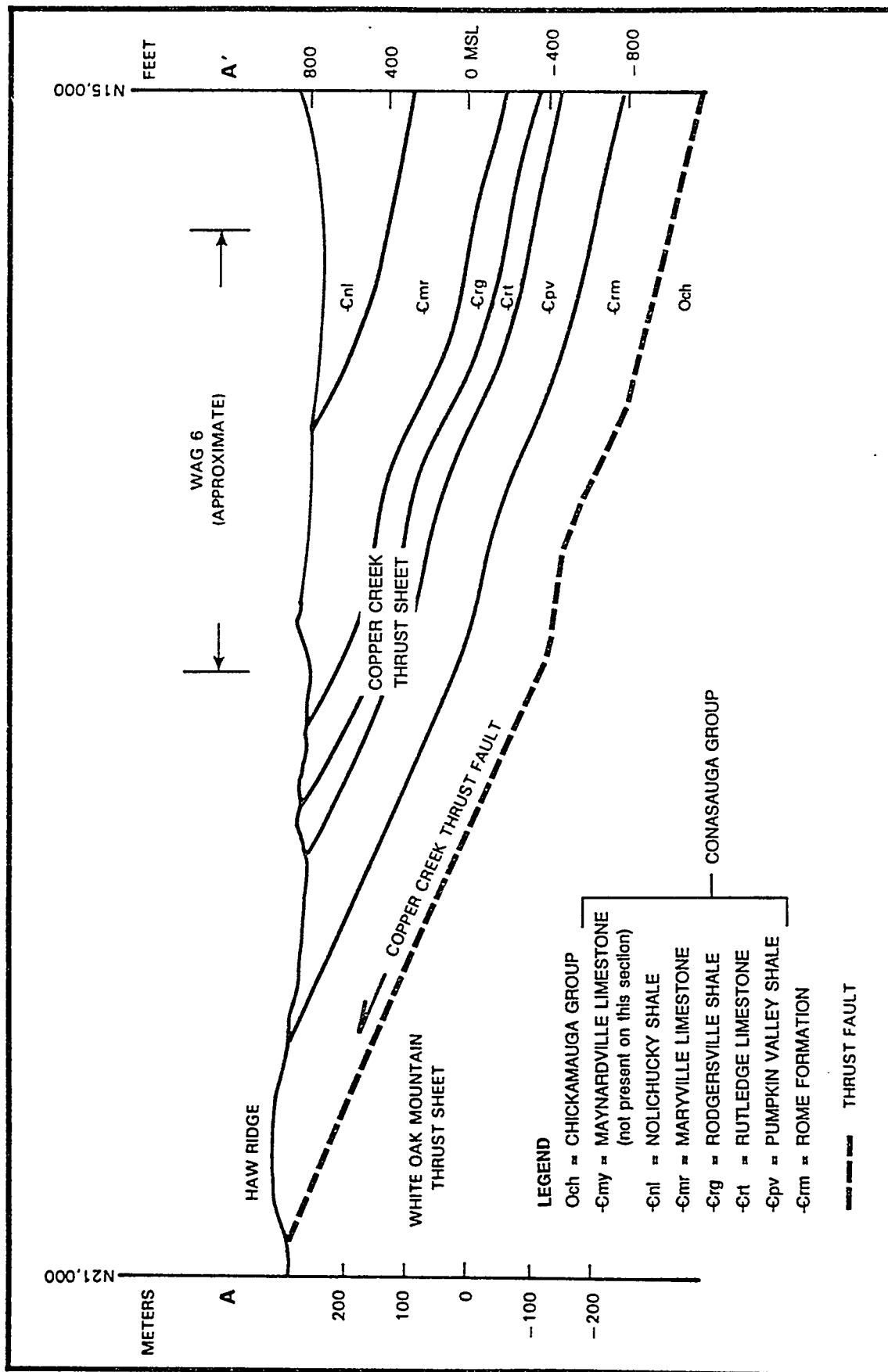
The Conasauga Group consists of the six formations described in Table 4-1. The surface expression of these formations in the vicinity of WAG 6 is shown on the generalized geologic map (Figure 4-3) as are the principal faults in this area.

Additionally, this figure shows the location of the generalized geologic cross section A-A' (Figure 4-4), oriented approximately perpendicular to strike, and transecting WAG 6, which shows the older rocks (Cambrian Conasauga Group) of the Copper Creek Thrust Sheet overriding the younger rocks (Ordovician Chickamauga Group) of the White Oak Mountain Thrust Sheet.'



SOURCE: Dreier et al. (1987).

FIGURE 4-3
GENERALIZED GEOLOGIC MAP
OF THE ORNL STUDY AREA



SOURCE: Dreier et al. (1987).

FIGURE 4-4
GENERALIZED GEOLOGIC CROSS SECTION A-A'

The general lithologic descriptions in Table 4-1 are derived from Haase, Walls, and Farmer (1985), and are based primarily upon continuous rock cores and geophysical logs from the 2700 deep ORNL-JOY No. 2 corehole located approximately 3.5 mi east-southeast of WAG 6. Figure 4-3 is adapted from the most recent geologic map of Melton Valley (Dreier et al., 1987). By developing geologic cross sections generally oriented perpendicular to bedrock strike and from subsequent structural mapping, Dreier et al. (1987) identified displacement of the formations of the Conasauga Group along tear faults. The most prominent of these tear faults is the WOC fault. The orientation of the WOC fault generally corresponds to the valley that underlies WOC and bisects Haw Ridge. Its motion is described as scissors-like, with the west fault block being the upthrown block. Visual evidence of horizontal motion along the fault at ground surface includes the topographic displacement on opposite banks of WOC (i.e., unaligned ridges along WOC in Melton Valley). Fault displacement is smallest at its northern and southern ends (40 ft) and greatest in the center (up to 350 ft). This feature is approximately 0.5 mi northeast of WAG 6 at its closest mapped location (Figure 4-3). Other tear faults are mapped elsewhere or are suspected to exist, primarily expressed as topographic anomalies at the ground surface; however, sufficient borehole data or map data currently do not exist to conclusively identify them. Such tear faulting is not uncommon in thrust terrains and simply represents differential yielding within the thrust block.

Two locally extensive thrust faults, trending roughly east-west across SWSA 6 were reported by Dreier and Toran (1989). Core examination combined with borehole geophysical data provide the primary evidence for these faults. The northern fault crosses the site north of the 49 Trench Area and across the southern border to the auger hole area. The southern fault traverses north of the south disposal area and passes south of the Tumulus

TABLE 4-1
GENERALIZED STRATIGRAPHY OF THE CONASAUGA GROUP

Formation	Member	Approximate WAG 6 Member Thickness ^(a) (ft)	Lithological Description
Maynardville Limestone	Chances Branch	144	Medium to thin-bedded buff and light gray dolostones, ribbon-bedded dolomitic calcarenites, wackstones, and micrites, and medium gray oolitic packstones and grainstones.
	Low Hollow	180	Wavy to evenly ribbon-bedded calcarenite and micrite alternating with oolitic packstones and grainstones.
Holichucky Shale	Upper Shale	62	Interstratified calcareous mudstones and limestones. The medium dark gray to grayish black, locally brownish black, mudstones are wavy to evenly stratified and thickly laminated. The light gray limestones are wavy ribbon-bedded to laminated micrites, oolitic fossiliferous wackstones, and packstones.
	Bradley Creek	29	Predominantly lenticularly to irregularly stratified, light to dark gray algal wackstones and packstones.
	Lower Shale	459	Numerous repeated cycles of limestone, calcareous mudstone, and shale. The red-brown to maroon or red-gray mudstones and shales are massively to thinly laminated. The carbonates are silty calcarenites, oolitic packstones, fossiliferous pelloidal wackstones, and intraclastic packstones and conglomerates. Bedding in the carbonates varies from parallel to wavy to lenticular.
Maryville Limestone	Upper ^(b)	246	Flat-pebble conglomerates interbedded with gray calcareous mudstones, wavy to lenticularly bedded modular micrite and dolomitic wackstones, wavy to lenticularly bedded calcarenite, and fossiliferous pelloidal packstone.
Maryville Limestone	Lower	213	Calcareous mudstone interbedded with wackstones, packstones, calcarenites and calcareous siltstones. Carbonate lithologies tend to be cyclical. Mudstones are thickly to thinly bedded; packstones are massive to thinly bedded.
Rogersville		131	Massive to laminated calcareous and noncalcareous mudstones and evenly bedded to wavy current-rippled calcarenites and subarkosic siltstones. Mudstones range from red-brown to gray and gray-green. An upper member--Craig--is the limestone-rich interval in the upper portion of this formation.
Rutledge Limestone		102	Upper and lower separated by a clastic-rich interval. Upper limestones consist of micrites, locally fossiliferous pelloidal wackstones and packstones, and silty calcarenites that are thinly bedded with highly variable stratification patterns. The middle interval consists of red-brown, red-gray, and gray mudstones and shales with interbedded laminae and lenses of subarkosic siltstone. The lowermost limestones are lenticularly bedded to mottled and bioturbated gray to gray-green wackstones and calcarenites interbedded with shales and mudstones.

TABLE 4-1 (Continued)

Formation	Member	Approximate On-Site Member Thickness ^(a) (ft)	Lithological Description
Pumpkin Valley Shale	Upper	157	Red-brown, red-gray, and gray mudstones and shales interbedded with subarkosic siltstones. The mudstones are massive to thinly bedded and evenly to wavy parallel stratified. Siltstones exhibit complex stratification that range from thinly laminated to thinly bedded with wavy to evenly parallel to nonparallel stratification. Glauconite pellets are commonly interbedded or found within other beds.
Pumpkin Valley Shale	Lower	151	Maroon-brown and maroon-gray bioturbated siltstones; they are massive to mottled and wavy or lenticularly bedded. The bioturbated siltstones are interbedded with gray and maroon-gray silty mudstone and evenly laminated and crossbedded siltstones.

(a) Approximate on-site thickness derived from JOY 2 corehole.

(b) Informal, site-specific division into Upper and Lower Members.

Source: Haase, Walls, and Farmer (1985).

Pad. These imbricate thrust faults have disturbed zones from 23 to 70 ft thick.

A site geologic map for WAG 6 is presented as Figure 4-5 (Dreier, 1986; Dreier et al., 1987). As shown on the map, there are two near-surface bedrock units within the site boundaries: the Nolichucky Shale and the Maryville Limestone. The placement of the contact is based on interpretation of deep drill hole data and topography. As Haase, Walls, and Farmer (1985) report, the lower contact of the Nolichucky is gradational, with the shale becoming increasingly calcareous towards the base of the unit.

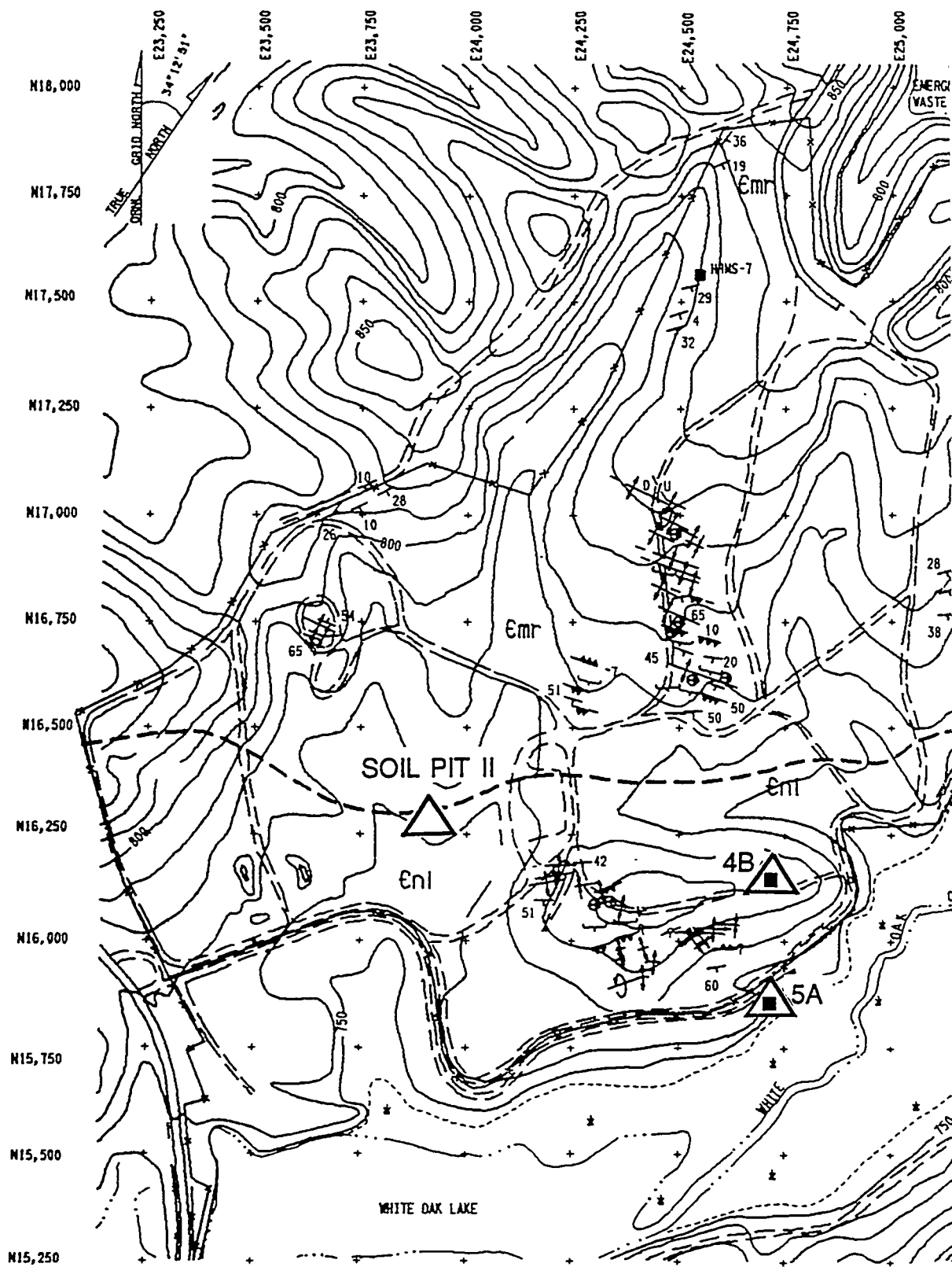
In general, the stratigraphic column within WAG 6 consists of the following in ascending order:

- o Unweathered, consolidated bedrock (limestone or shale)
- o An interval of weathered, unconsolidated bedrock, or saprolite, of varying thickness and degree of leaching and oxidation
- o A veneer of alluvial, colluvial or residual soils

Typical columns for representative topographic locations are shown in Figure 4-6 (Davis and Solomon, 1987). In fine-grained clastics, the transition from the surface to consolidated, unweathered bedrock tends to be gradual. In carbonate-rich sequences, weathering and alteration changes tend to be more distinct or locally abrupt (Webster and Bradley, 1988).

Dreier and Beaudoin (1987) present a summary of geologic data obtained from the HHMS wells drilled in WAG 6 (as well as other localities in Melton Valley).

These wells are in clusters of three wells each--80, 200, and 400 ft deep, respectively--at four sites (4, 5, 7, 8) in WAG 6. These localities are shown on Figure 4-5. The HHMS well log data provide information on the relative position of the Nolichucky



SOURCE: Dreier (1986) and Dreier et al. (1987).



GRA:[23,12]GE06.DGN;1

LEGEND

- PAVED ROADS
- GRAVEL ROADS
- STREAM
- GROUND SURFACE CONTOUR (ELEVATION INTERVAL = 10 FT)
- MARSHY AREA
- TREES
- FENCE
- APPROXIMATE GEOLOGIC CONTACT
- NOLICHUCKY SHALE
- MARYVILLE LIMESTONE
- THRUST FAULT TEETH ON HANGING WALL
- NORMAL FAULT
- ANTICLINE
- SYNCLINE
- TREND AND PLUNGE DIRECTION OF FOLD AXIS
- DIRECTION OF FOLD VERGENCE
- STRIKE AND DIP DIRECTION OF BEDDING
- HORIZONTAL BEDS
- STRIKE OF VERTICAL BEDS
- STRIKE AND DIRECTION OF HIGHLY DEFORMED BEDS
- HYDROSTATIC HEAD MONITORING STATION (GENERAL AREA OF WELL CLUSTER)
- REPRESENTATIVE STRATIGRAPHIC COLUMNS

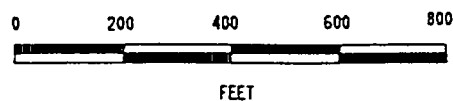


FIGURE 4-5
GEOLOGICAL MAP OF WAG 6

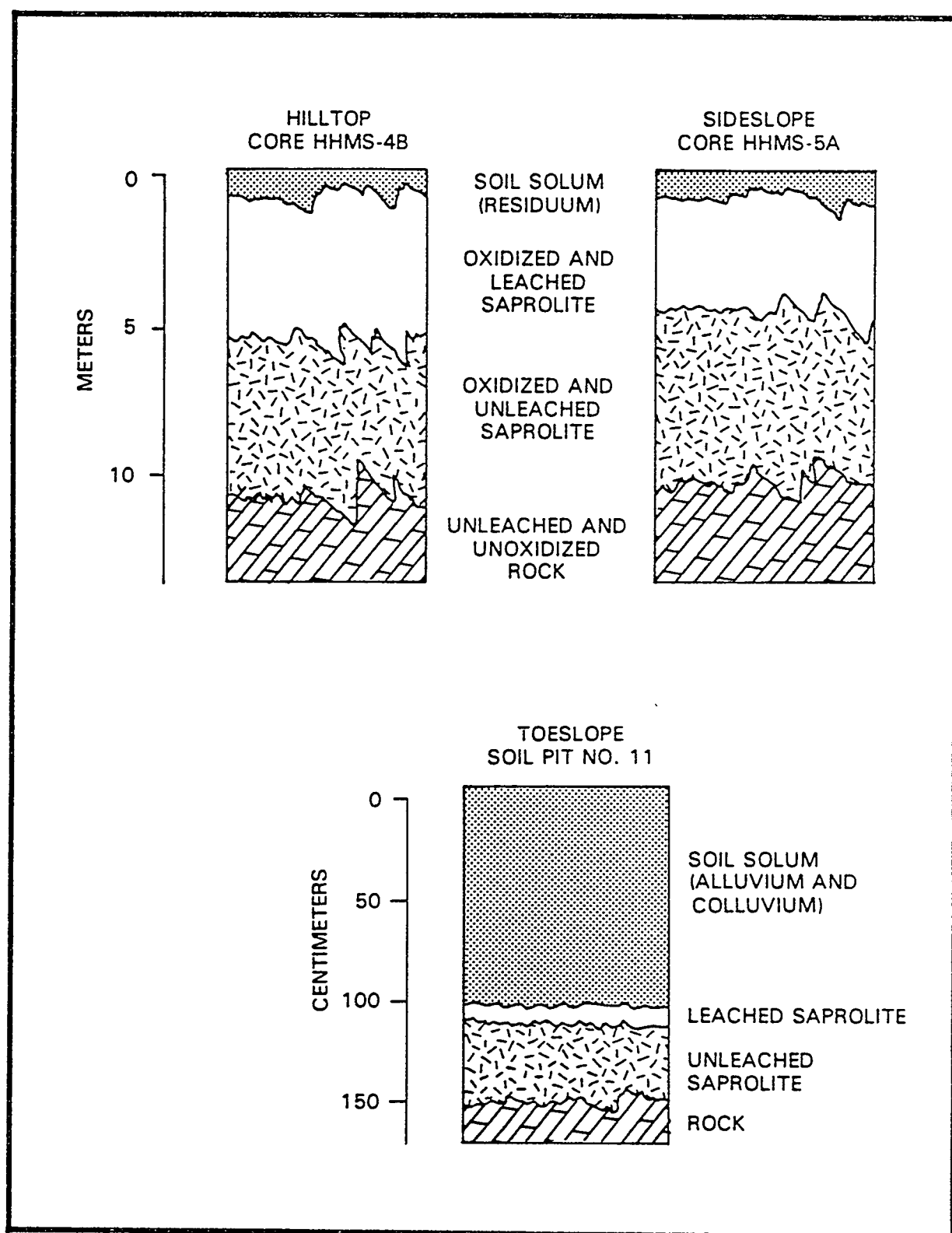


FIGURE 4-6
 REPRESENTATIVE STRATIGRAPHIC COLUMNS — WAG 6
 (location of columns shown on Figure 4-5)

Shale/Maryville Limestone, Maryville Limestone/Rogersville Shale contacts depicted in Figure 4-4.

Davis et al. (1984) collected information on the Maryville Limestone Formation through interpreting borehole and shallow geophysical data obtained in a siting study for the ETF, located near the northwest corner of WAG 6. Numerous joints and fractures were observed in all of the cores; some calcite filling occurs, commonly accompanied by other minerals. Small-scale (<0.8 ft) solution cavities with local mineralization were also observed in the cores. X-ray examination of selected cores from four of the ETF wells indicated that chlorite, illite, and mixed-layer illite/vermiculite were the major clay mineral constituents below the soil zone.

The development of at least two and, locally, as many as five pervasive joint sets is typical of Conasauga Group bedrock (Haase, Walls, and Farmer, 1985). Haase, Walls, and Farmer (1985) also report intraformational deformation of bedding with shearing, possibly representing a small-scale internal imbrication. Such structural complexity is documented with data obtained from within WAG 6 (Dreier and Beaudoin, 1986). In that study, 10 trenches were excavated, mostly within a north-south band across the site. The trenches were individually aligned according to known structural trends to maximize useful data recovery. Mapping of these trenches provides information on bedding, fracture, fault and fold orientations, and on fracture density. These data contribute to the development of an analytical model of the site.

Structural data from these trenches (and from additional mapping of other excavated areas) are summarized in Figure 4-5. Dreier and Beaudoin (1986) summarize the findings of the trench mapping program. In the northern part of WAG 6, bedding strikes generally N35°E and dips 22° to 33°SE, with gentle warping of the beds. In the central part of the site, bedding typically strikes

N50°E to N70°E and dips 32° to 40°SE. Small folds and minor faults are mapped in this area. In the southern part of the site (hill adjacent to White Oak Lake) bedding also strikes about N50° to N70°E, but deformation is more intense, with the occurrence of small-scale thrusting and overturned folds. The variation in general structural trends from one mapped area to the other is evident in Figure 4-5. The reason for this has not been determined, but it may be a manifestation of intraplate deformation (e.g., tear faulting) that can occur in thrust fault displacement.

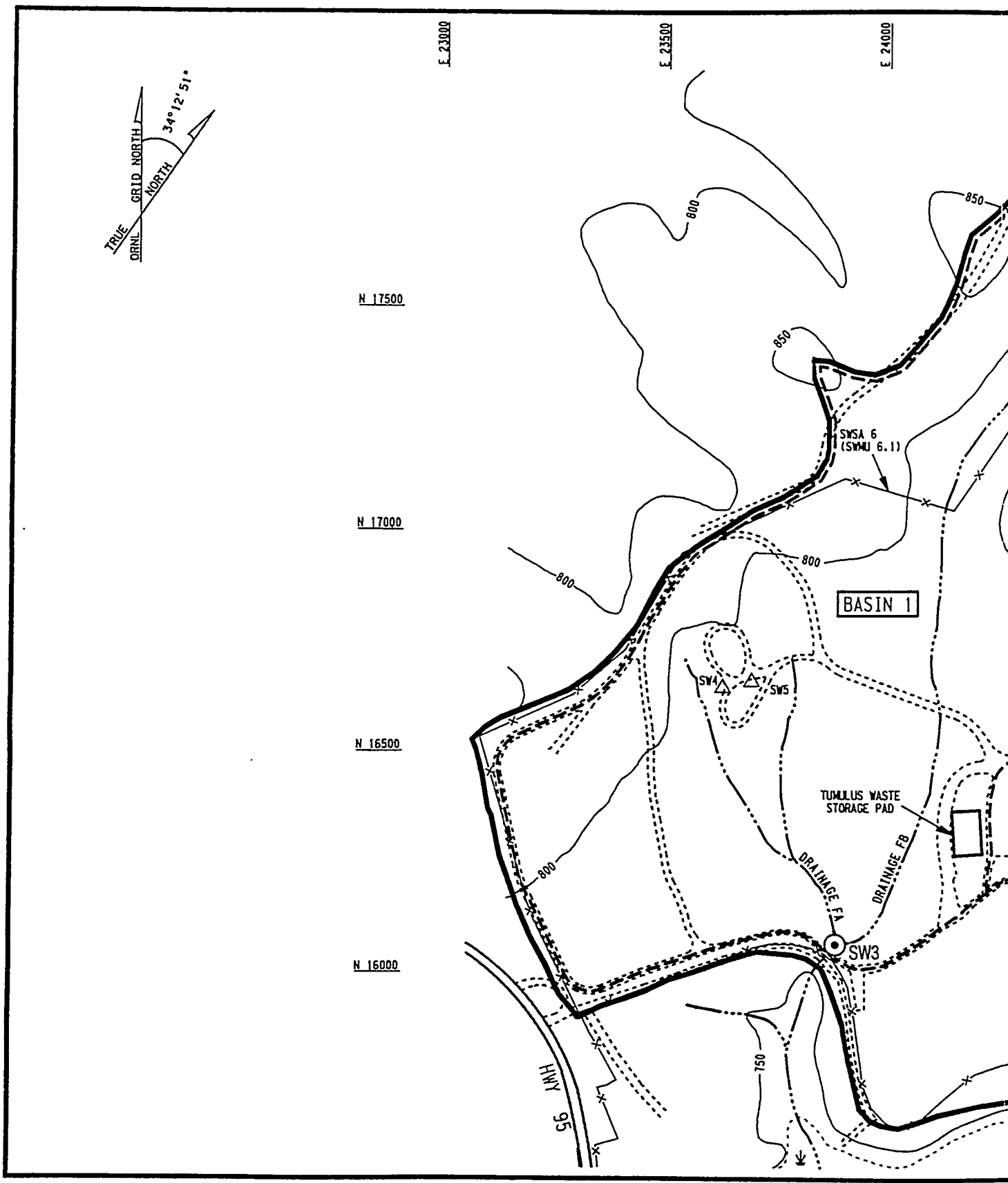
Studies by Sledz and Huff (1981), and Davis et al (1984), documented two major joint orientations near the ETF site. The first is a high angle joint set oriented perpendicular to geologic strike. The second is along bedding planes where signs of displacement (slickensides, polishing, offsets) were observed. Locally, the distribution and orientation of fractures are controlled by structural deformation (folding, thrust faulting) observed in the area. The size of fractures, some solutionally enlarged, range upwards to 6 in.; however, most are between 0.004 to .12 in. wide (Davis et al, 1984). Sledz and Huff (1981) further report gap widths measured from Conasauga Group drill core to range from .004 to .03 inches in siltstones and from .008 to < .004 inches in the shales.

Francis and Stansfield (1986) described work performed by Davis and Stansfield (1984) regarding the excavation and construction of a French drain in the Maryville Formation at WAG 6. It was found that the bedding dips locally from horizontal up to 60 degrees to the southeast due to folding of the strata. Three joint sets were observed in the weathered rock. Two of the joint sets were approximately vertical and closely spaced (approximately 0.4 in.). The third set is bedding parallel and may represent a bedding plane fault. Thus, minor thrusting may be associated with localized deformation of bedding and folding which is locally overturned.

4.4 SURFACE WATER HYDROLOGY AND SEDIMENTS

The WAG 6 site is characterized by gently to moderately sloping topography that is divided by natural gullies and seasonal streams into several sub-basins. As shown in Figure 4-7, there are three major sub-basins drained by four seasonal streams (FA, FB, DA, and DB). The drainage areas are shown at stream gages. These streams drain to the south to White Oak Lake and are usually dry during July, August, and September. In the northeastern and southern portions of WAG 6, runoff flows directly to White Oak Creek and White Oak Lake, respectively, because there are no visible drainages. White Oak Lake, which ultimately captures all of the WAG 6 surface runoff, is a tributary to the Clinch River (Figure 4-8), which in turn flows into the Tennessee River (Watts Bar Lake). Discharge from White Oak Lake enters the Clinch River approximately 2 mi downstream of Melton Hill Dam.

The White Oak Creek Watershed above White Oak Dam is approximately rectangular as shown in Figure 4-8 and contains approximately 6 mi² of drainage area (Tschantz, 1987). The natural soils of the watershed have slow infiltration rates resulting in high runoff yields. Tschantz (1987) considered these factors in addition to other hydrologic factors that affected the runoff in this watershed in his evaluation of the White Oak Lake spillway. In this study, he determined that the 10- and 100-yr, 24-h storm events would result in lake elevations of 751.65 and 754.08 ft MSL, respectively with the twin spillway gates fully closed. In addition, Tschantz (1987) showed that the probable maximum flood would result in a lake elevation of 762 ft MSL under these same conditions. Tschantz assumed a starting pool elevation of 744.0 ft which is close to the low pool level. A higher starting pool elevation would have resulted in higher



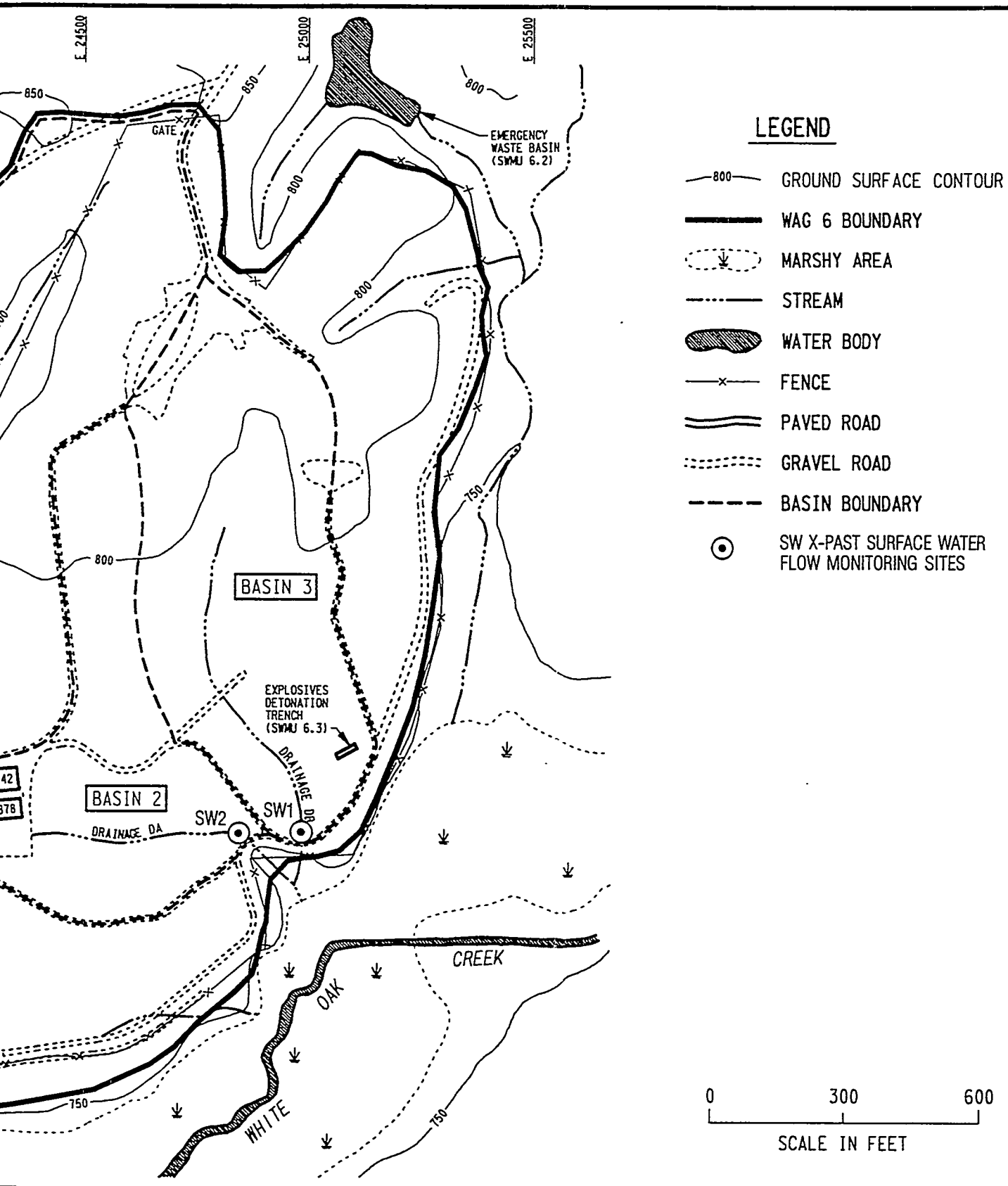


FIGURE 4-7
WAG 6 SURFACE
WATER FEATURES

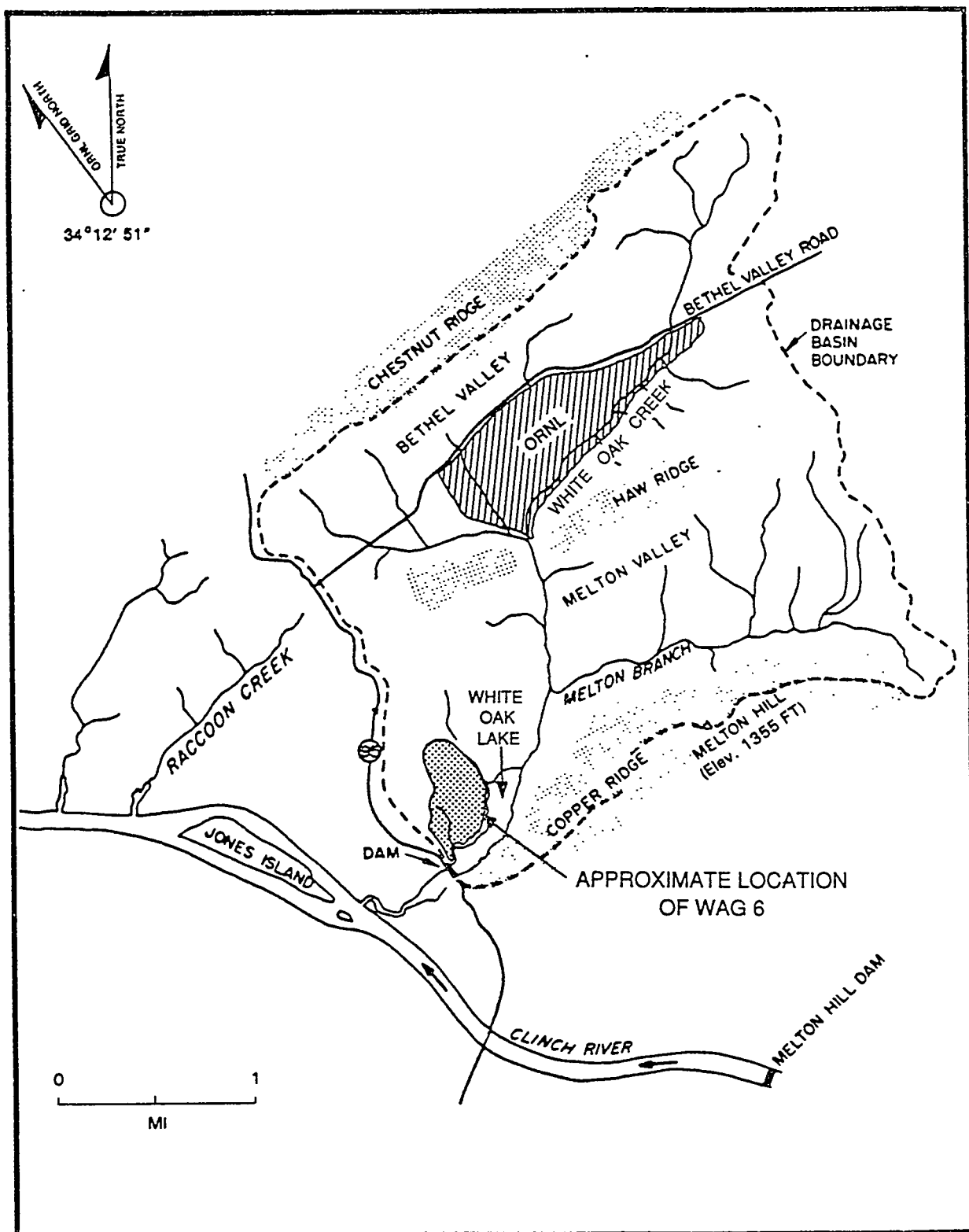


FIGURE 4-8
WHITE OAK CREEK WATERSHED

flood elevations. Flooding of SWSA 6 caused by the 100-yr, 24-h storm event would not involve any burial trenches; however, the probable maximum flood would inundate many of the trenches (used for animal wastes) in the lower part of the burial ground.

The surface waters of this area are rich in calcium, magnesium, and bicarbonate. They have a moderate hardness and typically have total dissolved solids ranging from 100 to 250 mg/L.

During evaluation of the surface water system in WAG 6, the peak flow rates were estimated by use of the HEC1 hydrologic modeling program at the outlets of Basins 1, 2, and 3 (Figure 4-7, SW3, SW2, and SW1). The peak flow rates at SW1, SW2, SW3 for a 25-yr, 24-h storm event are 42, 32, and 118 cfs, respectively. These flowrates account for changes in watershed runoff characteristics brought about by ICM capping and future construction of the Interim Waste Management Facility and TUMULUS 2 in Basin 1.

The average loss of water to the atmosphere annually by evapotranspiration is about 30 in., or approximately 57 percent of the mean annual precipitation of 52.2 in (Moore, 1988a). Evapotranspiration is the greatest from April 1 to November 5, during the growing season. Runoff to the streams is greatest in winter when evapotranspiration is low and precipitation is high.

In the fall, slow-moving high-pressure cells suppress rain and remain stationary for days, thus providing mild weather. Year-round mean temperatures are about 58°F, with a January mean of approximately 38°F and a July mean of approximately 77°F (Energy Systems, 1986). Temperatures above 100°F occur but are unusual. Low-level temperature inversions occur approximately 36 percent of the time (Energy Systems, 1986). Table 4-2 summarizes selected climatic conditions in the Oak Ridge area. Mean annual precipitation is variable around the Oak Ridge Reservation, being higher in the northwest portion and decreasing to the northeast

TABLE 4-2

MONTHLY CLIMATIC SUMMARY FOR THE NOAA STATION
IN OAK RIDGE (1965 - 1985)

Month	Temperature (°F)			Precipitation (in.)	
	Max	Min	Mean	Mean Rainfall	Mean Snowfall
January	49	29	38	5.3	3.4
February	51	31	41	5.3	2.6
March	59	36	47	5.6	1.3
April	71	47	59	4.4	0.01
May	79	54	67	3.6	0.0
June	85	63	74	4.0	0.0
July	87	66	77	5.6	0.0
August	87	65	76	3.8	0.0
September	81	59	70	3.3	0.0
October	71	47	59	2.7	0.0
November	58	36	47	4.2	0.5
December	49	31	40	5.7	2.5
Annual			58	53.5	10.3

Source: NOAA (1965-1985).

(Rothschild, 1984). The mean annual precipitation for stations near ORNL in the period 1954 - 83 was 52.2 inches (Moore, 1988a).

Preconstruction (i.e., prior to installation of ICM caps) sediment samples were obtained by Environmental Consulting Engineers (ECE) on October 17 and 18, 1988, at the locations depicted in Figure 4-9. The following observations were made from the grain size analysis performed on these samples:

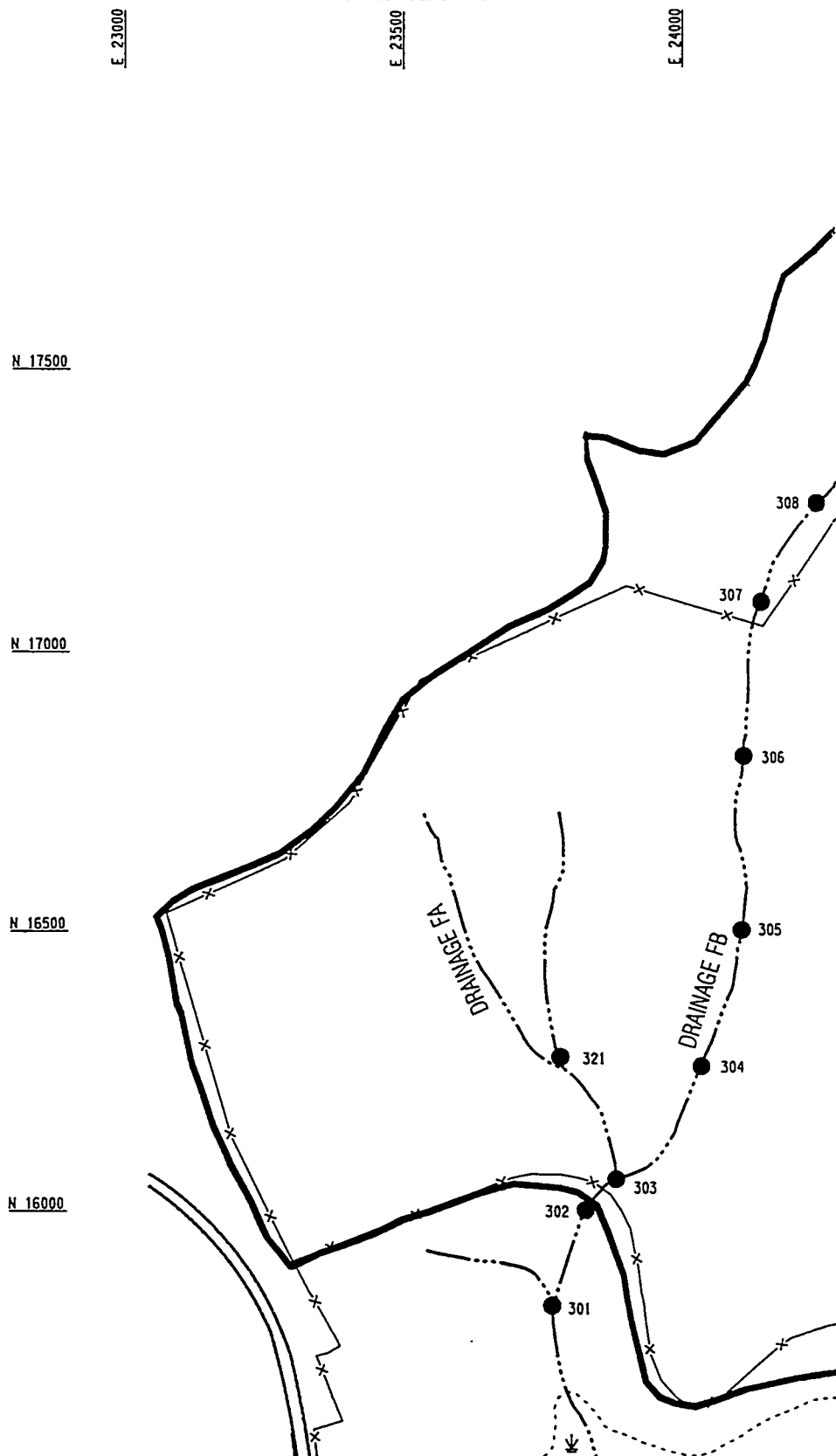
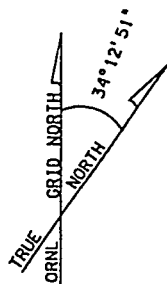
- o The grain-size distribution in sediment samples from each is approximately normal.
- o Each drainage shows an increase in fine sediments downstream.

These observations suggest that the grain-size distributions are representative of drainages that have evolved naturally without significant man-made disturbances.

ECE also collected sediment samples at the locations depicted in Figure 4-9 three times during construction and 1 month after completion of cap construction. A comparison of preconstruction and first during-construction grain-size curves indicates the effects of man-made disturbances. A decrease in fine sediments was noted. The results of the post-construction sediment sampling event are not currently available.

4.5 SOILS

WAG 6 surface soils are principally comprised of residual soils developed on the Maryville Limestone and the Nolichucky Shale of the Conasauga Group. In addition, alluvial deposits occur within the drainage paths and low-lying areas adjacent to White Oak Lake, and colluvium mantles some slopes. The residual soils are formed in situ. Their compositions and thicknesses are related to parent rock composition and weathering conditions, and topographic position. The depth of weathering is generally thin in the low-lying areas and thicker on the ridges. Consequently,



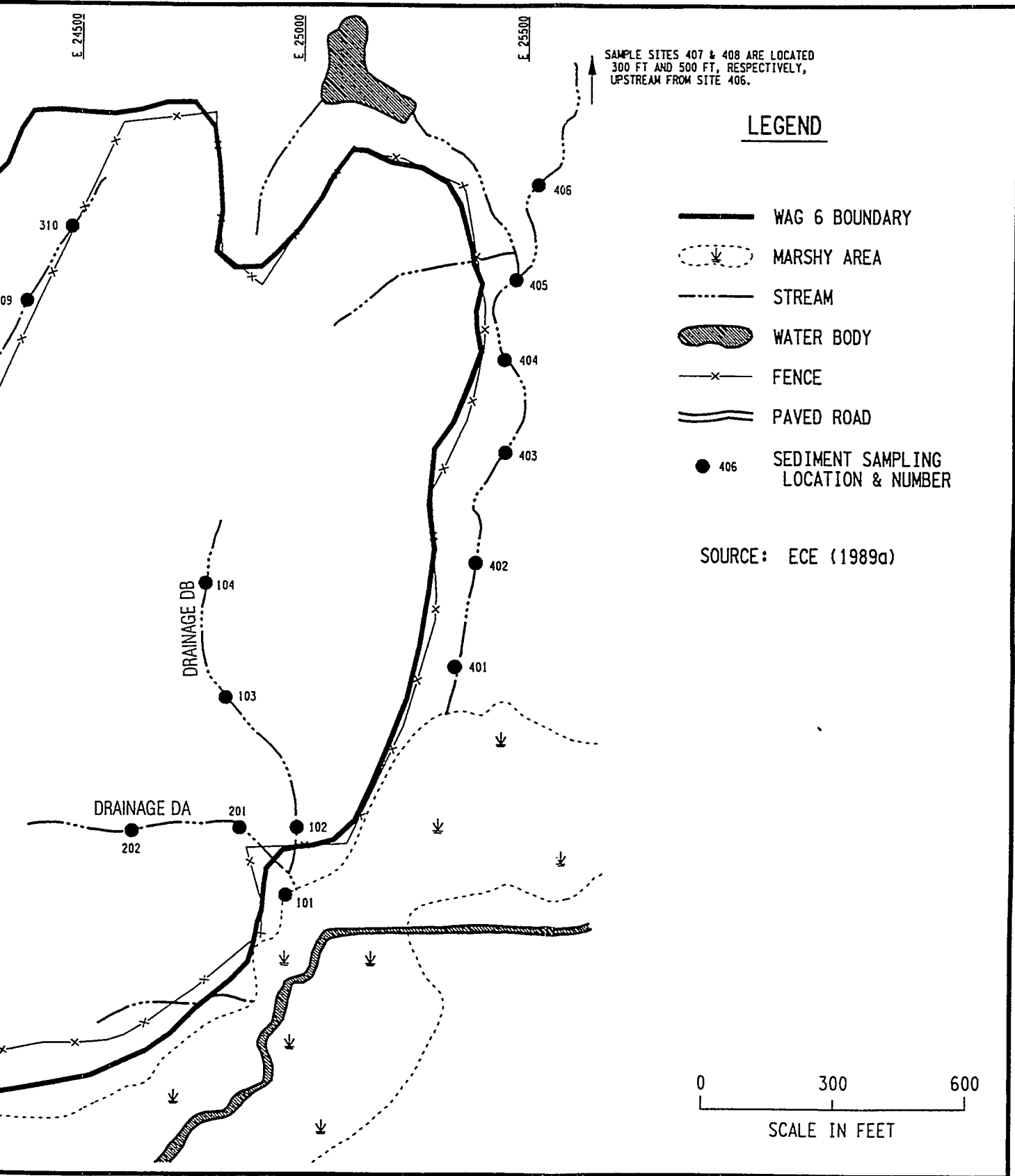


FIGURE 4-9
WAG 6 STREAM SEDIMENTS
SAMPLING LOCATIONS

a thin residual soil occurs on the ridges but is absent in low areas, where thick alluvial deposits may occur instead. These thin soils are documented in photographs and geologic description of 17 trenches in Davis et al, 1986.

The soils of WAG 6 and the surrounding area are generally characterized as being strongly leached and low in organic matter. They are further characterized as silty, although considerable amounts of clay may be present. The principal clay components of the Conasauga group are illite and vermiculite (Webster, 1976). The high silt and clay content of the Conasauga soils makes them less permeable and therefore more susceptible to overland runoff. Surface runoff and surface erosion have been dominant factors in maintaining the soils in a youthful state (poorly developed horizons) and with a shallow depth to bedrock (Lietzke and Lee, 1986). A large gradient in soil pH exists between the surface and calcareous bedrock. The soils are more acidic at the surface where most of the silicate mineral weathering and alteration of clay minerals occur. A soil pH range of 4.5 to 5.7 has been reported (Webster and Bradley, 1988).

The retardation potential of the soil is generally expressed as the distribution coefficient (K_d) and is related to the properties of the specific electrolyte and bulk properties of the soil. The capacity of a soil to undergo ion exchange is generally expressed as the cation exchange capacity (CEC) and is a function of the clay mineralogy of the soil. Table 4-3 provides a summary of measured K_d values for selected radionuclides for three soil profiles (trenches 334, 338, 342 at the ETF). Chemical weathering strongly affects soil formation in the Conasauga Group. In the rocks of the Conasauga Group, chemical weathering primarily results in the removal of the interstitial carbonate cement. Bedding and structural features of the parent rock are generally retained. In the Conasauga Group, the depth of weathering reportedly ranges up to 40 ft

TABLE 4-3

DISTRIBUTION COEFFICIENTS OF SELECTED RADIONUCLIDES FOR SOILS
FROM THREE DEPTH PROFILES OF THE ENGINEERED TEST FACILITY SITE

Trench	Depth (cm)	Kd (L/kg)						
		²⁴¹ Am	⁸⁵ Sr	¹³⁷ Cs	⁶⁰ Co	¹²⁵ I	⁵⁹ Fe	⁵¹ Cr
334	20	17,100	342	18,400	435	21.4	44,600	895
334	40	4,620	79	29,100	102	18.5	59,000	5,460
334	60	1,950	117	28,500	117	22.8	59,000	3,190
334	100	2,770	544	58,900	570	2.2	59,000	615
334	130	1,770	724	104,000	730	1.1	7,840	482
334	150	2,160	831	67,100	725	4.2	59,000	238
334	180	5,810	757	190,000	845	10.5	59,000	445
334	200	2,000	548	52,900	825	11.3	59,000	126
338	20	7,820	236	32,000	223	4.1	10,900	4,240
338	40	5,610	298	64,800	293	11.1	59,000	7,290
338	100	3,220	759	57,400	1,740	18.6	59,000	112
338	130	2,020	782	34,700	675	0.3	9,570	1,460
338	150	5,240	248	64,800	1,020	3.8	59,000	48
338	180	4,040	458	69,600	762	2.6	33,000	334
338	200	17,100	126	48,000	4,810	0.1	4,120	17
342	20	3,220	224	49,900	219	10.1	12,500	8,300
342	40	2,720	383	52,500	311	14.8	59,000	5,300
342	60	30,000	729	75,200	560	13.8	59,000	8,300
342	100	1,770	327	48,500	388	23.0	56,200	327
342	130	2,160	415	91,200	447	14.0	59,000	1,350
342	150	4,370	678	96,500	889	31.7	59,000	572
342	180	3,840	821	75,100	839	24.0	59,000	424
342	200	3,220	1,010	78,900	854	16.0	59,000	120
Mean		5,670	494	64,100	782	11.7	46,800	2,220
Standard deviation		6,630	266	34,600	929	9.0	20,700	2,780

Source: Davis et al., 1984.

and is closely tied to topography with thinner zones generally in low-lying areas and thicker zones on the ridges (Webster, 1976). Davis et al. (1987) state, "Trends in pH, clay mineralogy, clay content and distribution, iron and manganese oxide content and distribution, cation exchange capacity, and physical properties change with depth below the surface." Thus, variation in soil properties is a consideration in evaluating radionuclide migration.

Within some areas at SWSA 6, native soils have been reworked and fill materials imported to accommodate operational and disposal activities such as the construction of the French drain, trenches, building foundations, and the Tumulus pad. The disturbance has altered the natural structural fabric and mineralogy of soils in these areas creating zones of higher permeability, which often provide a network of conduits for the collection and conveyance of fluids, including leaked and spilled materials.

Davis et al. (1987) found that except for some localities within the Maryville soils and some alluvial areas, average soil thickness in WAG 6 is thin--generally less than 3 ft above the weathered, in-place rock. In the 54 soil borings drilled as part of the RFI, auger refusal occurred at depths ranging from 5 to 54' (average of 20 feet). Soil thickness was found to range from 5 to 15 feet and was usually underlain by a weathered bedrock/saprolitic zone which comprised the remainder of the unconsolidated overburden. WAG soils encountered displayed good sorption properties and relatively high clay content.

4.6 HYDROGEOLOGY/GROUNDWATER

The groundwater in the Melton Valley portion of the Copper Creek Thrust appears to consist of two distinct flow systems: a shallow fresh water flow system (less than 150 ft in depth) and a

deeper, more saline system. The relatively sharp transition from fresh to saline water indicates that there is little mixing, suggesting only limited deep circulation of the fresh ground water system.

Water table depths range from less than 2 ft to more than 60 ft below ground surface. Seasonal water table fluctuations of up to 15 ft have been observed in wells in or adjacent to WAG 6. Water level data and hydrographs for nearly one hundred wells at WAG 6 has been recorded over the period 1975 - 1979 (Webster et al, 1980) more recent (through 1987) data is available in Davis et al (1984). The water table is encountered in both bedrock and unconsolidated regolith depending upon topographic position. Webster and Bradley (1988) have suggested that fluctuations in the water table elevations impact groundwater flow directions in Melton Valley. During high water table conditions, the water table extends up into the unconsolidated saprolite and soil zone overlying bedrock, Groundwater flow rates and flow direction are then controlled by hydraulic gradient and tend to roughly follow topographic expression, flowing radially away from topographic highs. Conversely, during the dry season or periods of extended drought, the water table drops below the overburden/bedrock interface. Ground water flow rates and directions are then controlled by the inherent permeability of the bedrock formation, secondary permeability caused by fractures and joints, geologic structure, and man-made disturbances (i.e, trenches, auger holes). Those controlling factors create anisotropic flow conditions in the saturated bedrock, thereby decreasing flow predictability. With regards to hydraulic conductivity, statistical studies by Moore (1988a) (Tables 4-4 through 4-7) suggest that hydraulic conductivity generally decreases with depth and that there is minimal differentiation between formations or lithologies or between overburden and bedrock. Moore (1988a) predicts that the bulk of storm event precipitation enters the very shallow subsurface and moves laterally through

TABLE 4-4

RELATIONSHIP OF HYDRAULIC CONDUCTIVITY TO TYPE OF AQUIFER MATERIAL

Aquifer Type	Number of Values	Hydraulic Conductivity (m/d)				
		Geometric Mean	Mean Minus One Standard Deviation	Mean Plus One Standard Deviation	Minimum Value	Maximum Value
Regolith(a)	182	0.044	0.0064	0.31	0.00019	48
Bedrock	225	0.042	0.0061	0.29	0.00020	7.6
Population	407	0.041	0.0058	0.29	0.00019	48

(a) Includes 77 wells screened across regolith-bedrock contact.

Source: Moore (1988a).

TABLE 4-5
RELATIONSHIP OF HYDRAULIC CONDUCTIVITY TO GEOLOGIC FORMATION OR GROUP

Geologic Unit	Number of Values	Hydraulic Conductivity (m/d)				
		Geometric Mean	Mean Minus One Standard Deviation	Mean Plus One Standard Deviation	Minimum Value	Maximum Value
Rome	7	0.13	NA (a)	NA (a)	0.0027	7.3
Conasauga	241	0.050	0.010	0.25	0.00020	2.1
Knox	36	0.078	0.0045	1.3	0.00028	48
Chickamauga	123	0.029	0.0037	0.23	0.00019	7.6
Population	407	0.041	0.0058	0.29	0.00019	48

(a) Not applicable because of the small number of wells.

Source: Moore (1988a).

TABLE 4-6

STATISTICAL CHARACTERISTICS OF HYDRAULIC CONDUCTIVITY VALUES FOR
BEDROCK LITHOLOGY OF THE WATER-PRODUCING INTERVALS

Lithology	Number of Values	Hydraulic Conductivity (m/d)					Maximum Value
		Geometric Mean	Mean Minus One Standard Deviation	Mean Plus One Standard Deviation	Minimum Value		
Dolostone	19	0.15	0.019	1.1	0.0019	6.1	
Limestone	85	0.026	0.0028	0.25	0.00019	7.6	
Limestone and shale	71	0.050	0.011	0.23	0.00065	2.6'	
Shale and limestone	31	0.037	0.0058	0.24	0.00022	0.59	
Shale	40	0.031	0.0070	0.14	0.0010	0.41	
Population	302	0.040	0.0063	0.26	0.00019	7.6	

Source: Moore (1988a).

TABLE 4-7
STATISTICAL CHARACTERISTICS OF HYDRAULIC CONDUCTIVITY VALUES FOR
SELECTED CLASSES OF WELL DEPTH

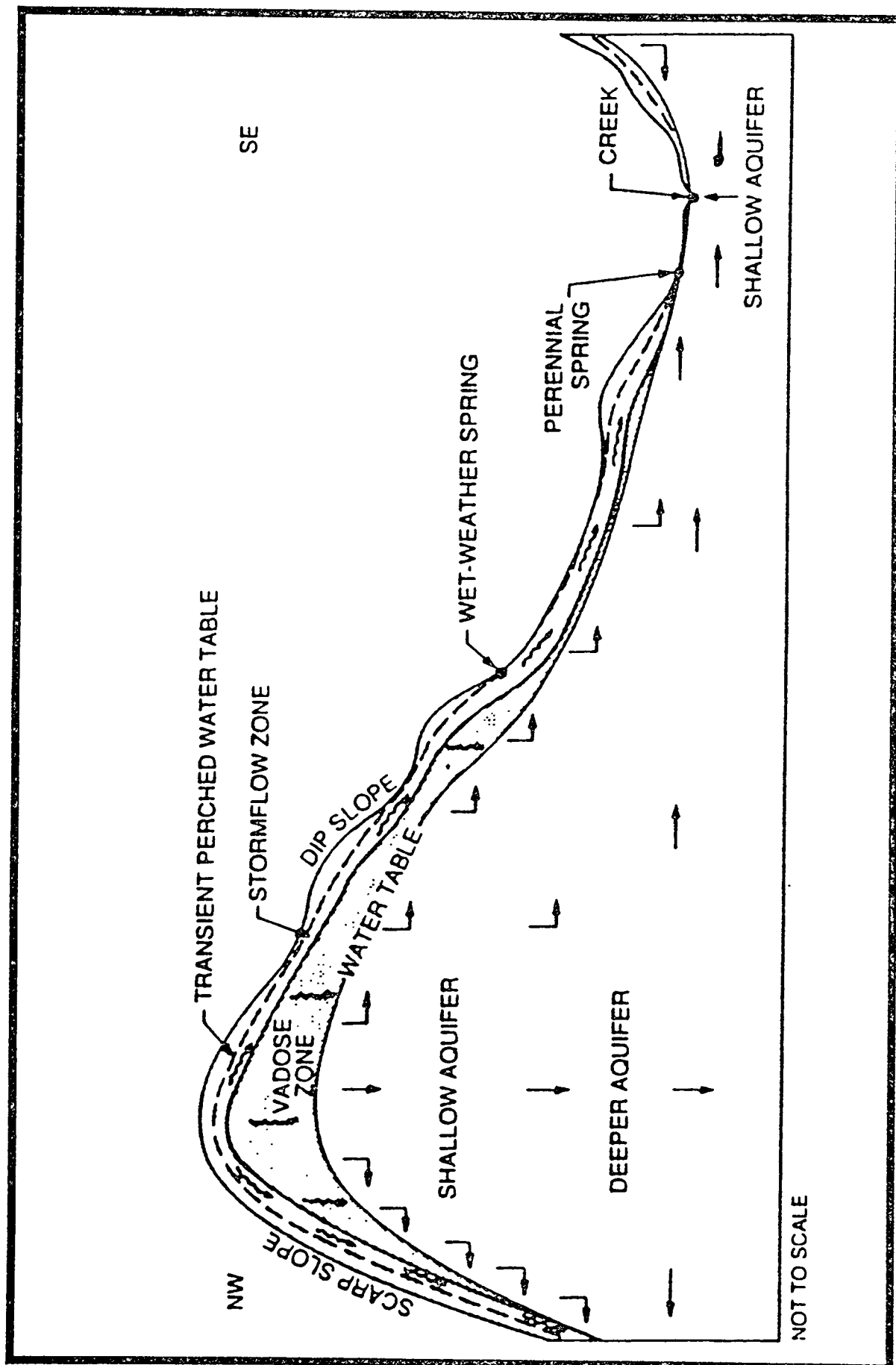
Well Depths (m)	Number of Values	Hydraulic Conductivity (m/d)					Minimum Value	Maximum Value
		Geometric Mean	Mean Minus One Standard Deviation	Mean Plus One Standard Deviation				
0 - 5	74	0.044	0.0070	0.28	0.00019	1.3		
5 - 10	166	0.054	0.011	0.26	0.00060	8.9		
10 - 15	59	0.052	0.0069	0.39	0.00020	7.6		
15 - 20	44	0.039	0.0040	0.38	0.00056	48		
20 - 30	37	0.014	0.0017	0.12	0.00022	2.9		
>30	407	0.041	0.0058	0.29	0.00019	48		

Source: Moore (1988a).

the highly permeable root zone, identified as the stormflow zone, to be discharged in the surface drainageways (Figure 4-10). Trenches cut through the stormflow zone are believed to interrupt this process in many areas of WAG 6. In low permeability saprolite materials, the trenches serve to accumulate the water creating a bathtubbing effect. Following the conclusion of the storm event and the subsequent discharge of shallow groundwater to streams, the water retained in the trenches can slowly migrate vertically to the water table and hence flow in the directions dictated by water table gradients in the fractured media.

Types of flow and contaminant transport mechanisms are dictated by the location of the trenches within the hydrogeologic setting. Cases I through IV (Figure 4-11) demonstrate how disposal units (trenches and auger holes) may interact with a setting such as that shown in Figure 4-10. By combining these figures, the schematic setting of the flow of groundwater and potential transport of contaminants in the shallow subsurface at WAG 6 is developed (Figure 4-12).

Ultimately, it appears that stormflow zone water and some shallow groundwater will discharge into surface drainages dissecting WAG 6. An along-strike flow component is likely, as is a down-dip flow component when water gets into the saturated zone in the shallow, fractured bedrock. Because of the transition from fresh to saline water at about 150 ft, deep circulation of groundwater is not suspected. Conventional hydrologic wisdom would have this unit discharging to White Oak Lake to the southeast or to the Clinch River to the southwest, but flow directions and discharges are unconfirmed at present. By projection of bedrock flow patterns developed from cross-sections at adjacent SWSA 5, Webster and Bradley (1988) inferred that the differences in potentiometric heads and a comparatively thin



SOURCE : MOORE (1988).

FIGURE 4-10
SUBSURFACE ZONES AND DIRECTIONS OF GROUNDWATER FLOW

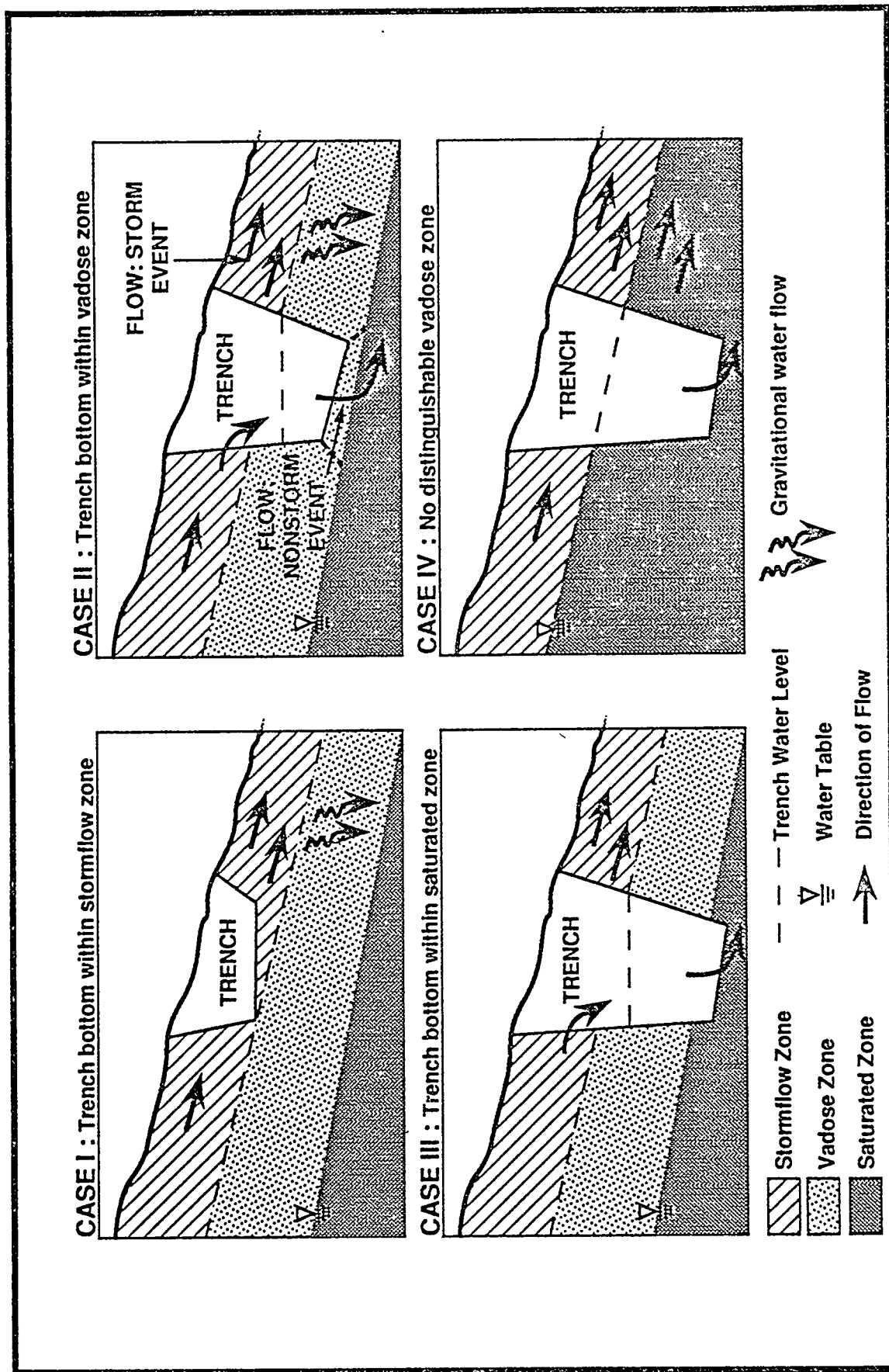


FIGURE 4-11
CONCEPTUAL HYDROLOGIC SETTINGS FOR TRENCHES IN WAG 6

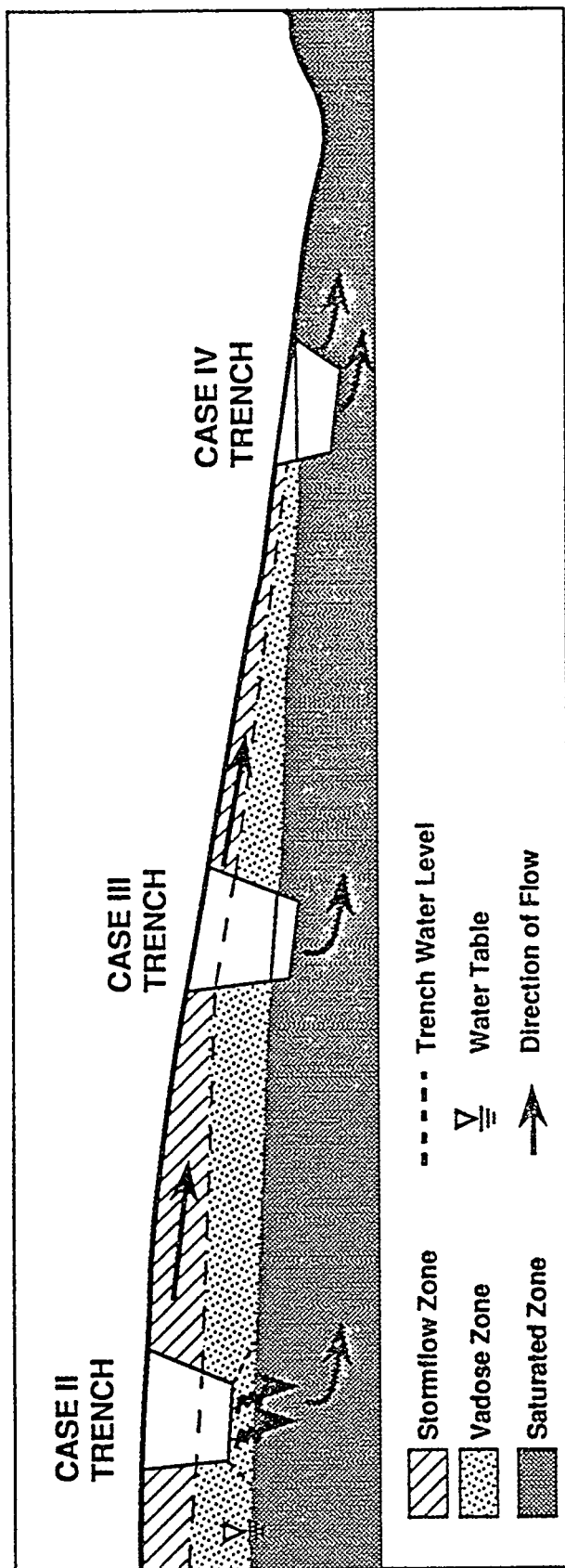


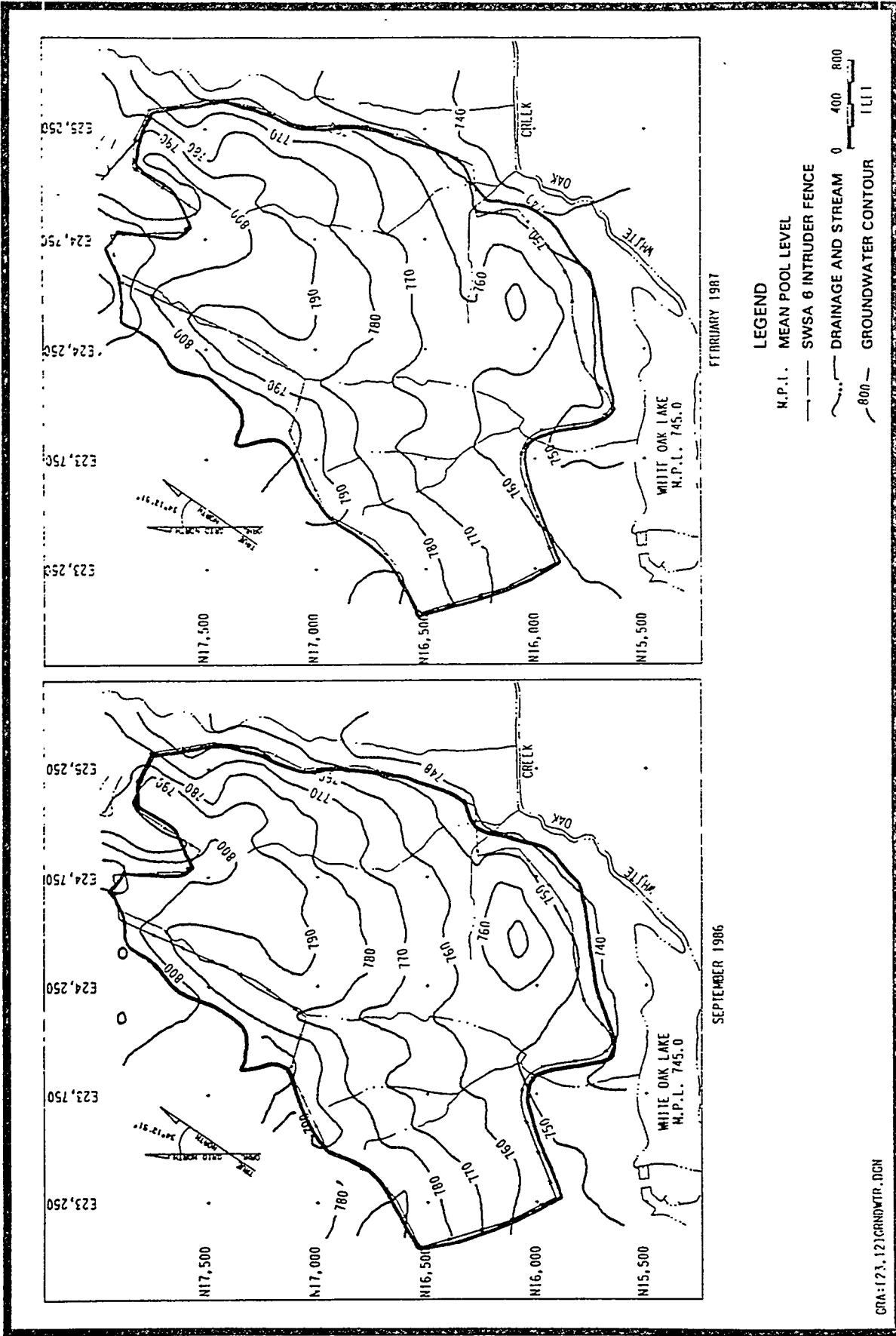
FIGURE 4-12
CONCEPTUAL GROUNDWATER FLOW AND
CONTAMINANT TRANSPORT IN WAG 6

saturated zone in bedrock do not favor the development of deep flow through bedrock beyond the major drainage elements such as White Oak Creek.

Within WAG 6, groundwater occurs under unconfined conditions. Local perched conditions are also reported; however, some perched conditions are likely to be a construction artifact of trench closure, and in other instances, may represent detection of a transient flow condition in the unsaturated zone subsequent to heavy precipitation (i.e., stormflow zone).

Ambient groundwater levels reflect local topography and seasonal variations. Figure 4-13 shows groundwater level contours for September 1986 and February 1987 (Davis et al., 1987). Depth to groundwater fluctuates seasonally as a function of topographic location. Webster and Bradley (1988) report depths to groundwater in winter range from essentially ground surface to 45 ft; in fall, at the same locations, depths range from 1 to 2 ft to nearly 60 ft below ground surface. As would be expected, fluctuations are greatest in the higher, northern part of the site where groundwater is deeper. Depths fluctuate less in the lower elevation drainage areas where groundwater level is high. It should be noted that, with the construction of impermeable caps over large portions of WAG 6 as part of the ICM during the winter and spring of 1989. It is anticipated that water-level data will show that the water table is depressed to some extent beneath the caps, due to the local decrease in recharge by precipitation.

As is evident from the contour map (Figure 4-13), the hydraulic gradient is in the direction toward White Oak Lake and the adjacent marshy area. In the northeastern corner of the site, there is a drainage divide, and groundwater in a portion of the high-level disposal trench area flows eastward down a steep gradient toward the tributary stream. Locally, flow direction may be toward the secondary surface drainage alignments within



GRA-1(21,12)GRNDWTR.DCH

SOURCE: Adapted From Davis et al. (1987).

FIGURE 4-13
GROUNDWATER LEVEL CONTOURS — WAG 6

the area and toward the French drain in the central part of the site. Variations in lithology may also have a localized effect on groundwater flow.

Webster and Bradley (1988) report an average hydraulic gradient of 0.055 (290 ft/mi) for the central and western part of the site and a gradient of about four times this value in the east/northeast area of higher topography and steeper slopes. Gradient varies seasonally and is further influenced by local features (e.g., in the vicinity of the French drain).

Groundwater in WAG 6 is recharged by flow from the higher terrain to the northwest of the site and by infiltration of precipitation across the site, principally in the upland area in the north-central part of WAG 6 around the SWSA 6 access road and the high-activity disposal area. Other topographically higher areas within WAG 6, such as the hill adjacent to White Oak Lake, can provide recharge, but the net effect of this is probably minimal.

Ground water flow in the unconsolidated weathered bedrock zone is anisotropic owing to the nature, spacing and orientation of micro-and macrofractures. A number of ranges of hydraulic conductivity have been reported (ORNL, 1986; Webster and Bradley, 1988; Davis et al., 1987; Moore, 1988). A representative value appears to be on the order of 10^{-4} to 10^{-5} cm/sec, though the collective range is 10^{-2} to 10^{-7} cm/sec. The hydraulic conductivity of bedrock is about one order of magnitude less than that of the unconsolidated material (Davis et al., 1987). The relative rate of change in hydraulic conductivity through the vertical section of the unconsolidated weathered bedrock is not known.

The movement of groundwater in the upper part of the saturated zone is a product of the hydraulic gradient, the primary hydraulic conductivity of the aquifer (principally

unconsolidated, weathered bedrock), and the secondary hydraulic conductivity resulting from the pervasive fracturing. Where weathering decomposition and fracturing are most pervasive, groundwater flow is likely to follow the most direct downgradient path (e.g., across bedding). As these conditions become less pervasive (i.e., with depth), flow becomes more directional along bedding or along fractures or faults. Depending on location and depth, the flow direction can vary significantly over a limited area and thus be difficult to predict. However, over the larger area, these factors apparently average out, and general predictions regarding flow direction can be made.

Webster and Bradley (1988) report a number of tracer and monitoring tests (including work by: Olsen et al., 1983; Vaughn et al., 1982) that indicate gradient-dominated flow and structurally controlled flow within specific areas. Davis et al. (1987) report that some tracer test results indicate local cross-gradient flow that is likely influenced by bedding strike-parallel extension fractures. However, interpretation of measured groundwater levels indicates, however, an averaging of conditions over the site with hydraulic gradient being the primary control on flow (Webster and Bradley, 1988). Davis et al. (1987) state, "Local variations in flow directions may deviate in the direction of fractures, but the overall trend of groundwater flow is approximately the same as the areal hydraulic gradient, as illustrated by the water table contour maps." Moore (1988a) concludes that hydraulic gradients are controlled to some extent by the nonlinear, complex flow paths and changes in hydraulic potential on steep hillsides.

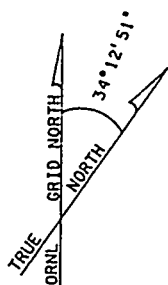
Numerous wells have been installed throughout the operational history of WAG 6, including nine wells that were installed in the Phase 1, Activity 1 of the RFI. Many of the previously installed wells were placed either for research purposes or to observe the water levels inside burial trenches; as such, information

concerning these wells is either not available or is of a very general nature. The location of selected groundwater wells in WAG 6 is shown on Figure 4-14.

Three recent well installation programs have been completed. The first of these recent programs was a series of 21 piezometers installed in the summer of 1986; these provide lithologic and water-level data. These piezometers are constructed of polyvinylchloride (PVC) with sandpacks, grout seals, and caps to prevent infiltration of surface water and rainfall. Water-level data collected from these installations biweekly have been used to generate preliminary groundwater maps that were used to help design a network of 30 groundwater compliance wells. The locations of the 21 piezometers and the 30 water quality wells are shown on Figure 4-14.

The 30 groundwater quality monitoring wells were drilled and installed in early 1987 (Hyde, 1987). For compliance purposes, 21 of these wells are located along the boundary of WAG 6. The remainder are located within the burial site. Wells are constructed with stainless steel screens and casings and were drilled and installed according to strict RCRA protocol, as described in the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (EPA, 1986c).

During Phase 1, Activity 1 of the RFI at WAG 6, nine wells were installed. The locations of these wells are shown in Figure 4-14. Three of the nine wells were installed at a depth above the anticipated seasonal high water table in an attempt to assess flow in the stormflow zone. It was anticipated that water would collect in these "vadose" zone wells during storm events to provide data regarding possible contaminate flow. No measurable amount of water has been recorded to date in these wells. Six other wells installed at WAG 6 as water table wells, have been



N 17500

N 17000

N 16500

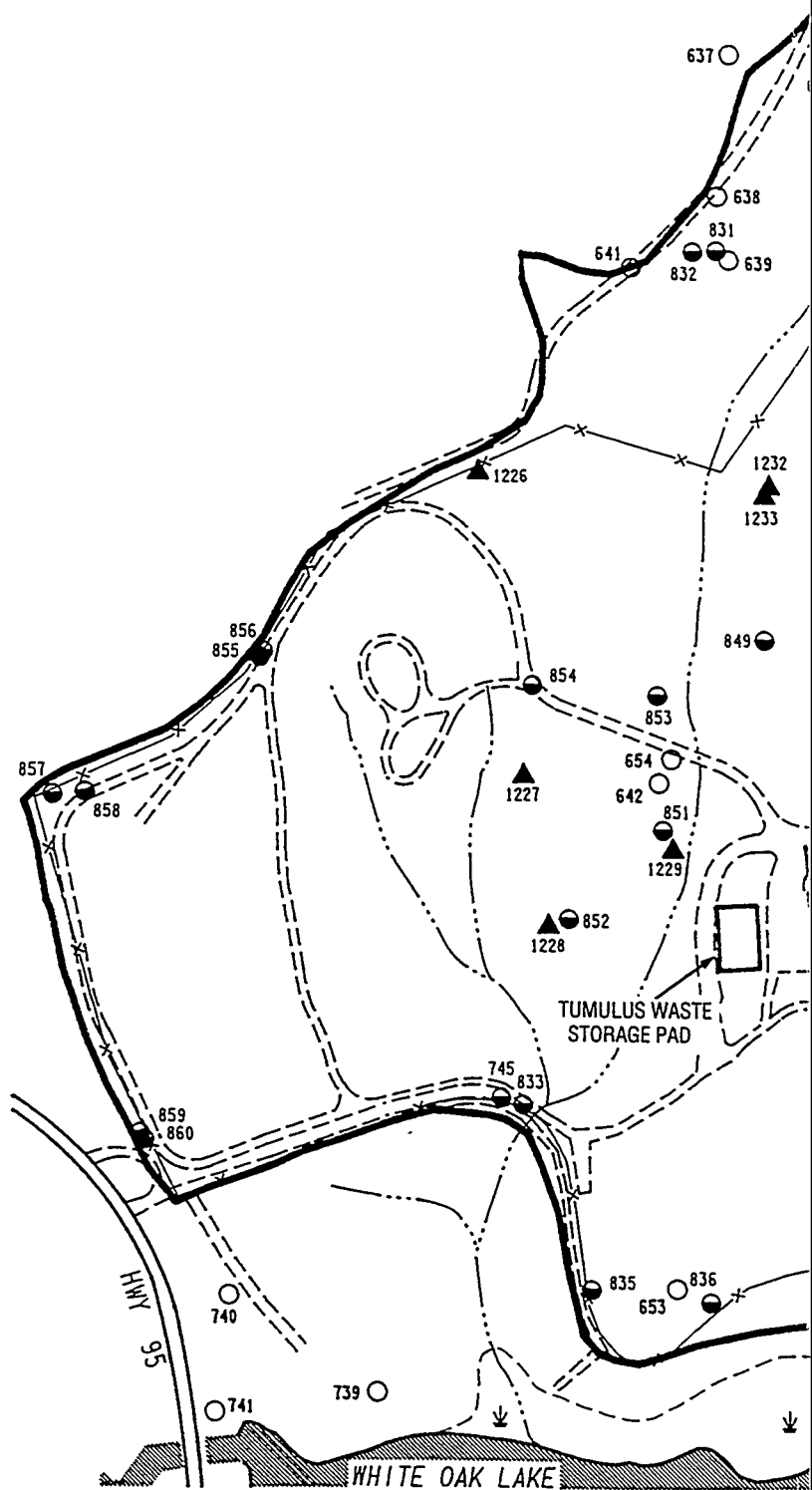
N 16000

N 15500

E 23000

E 23500

E 24000



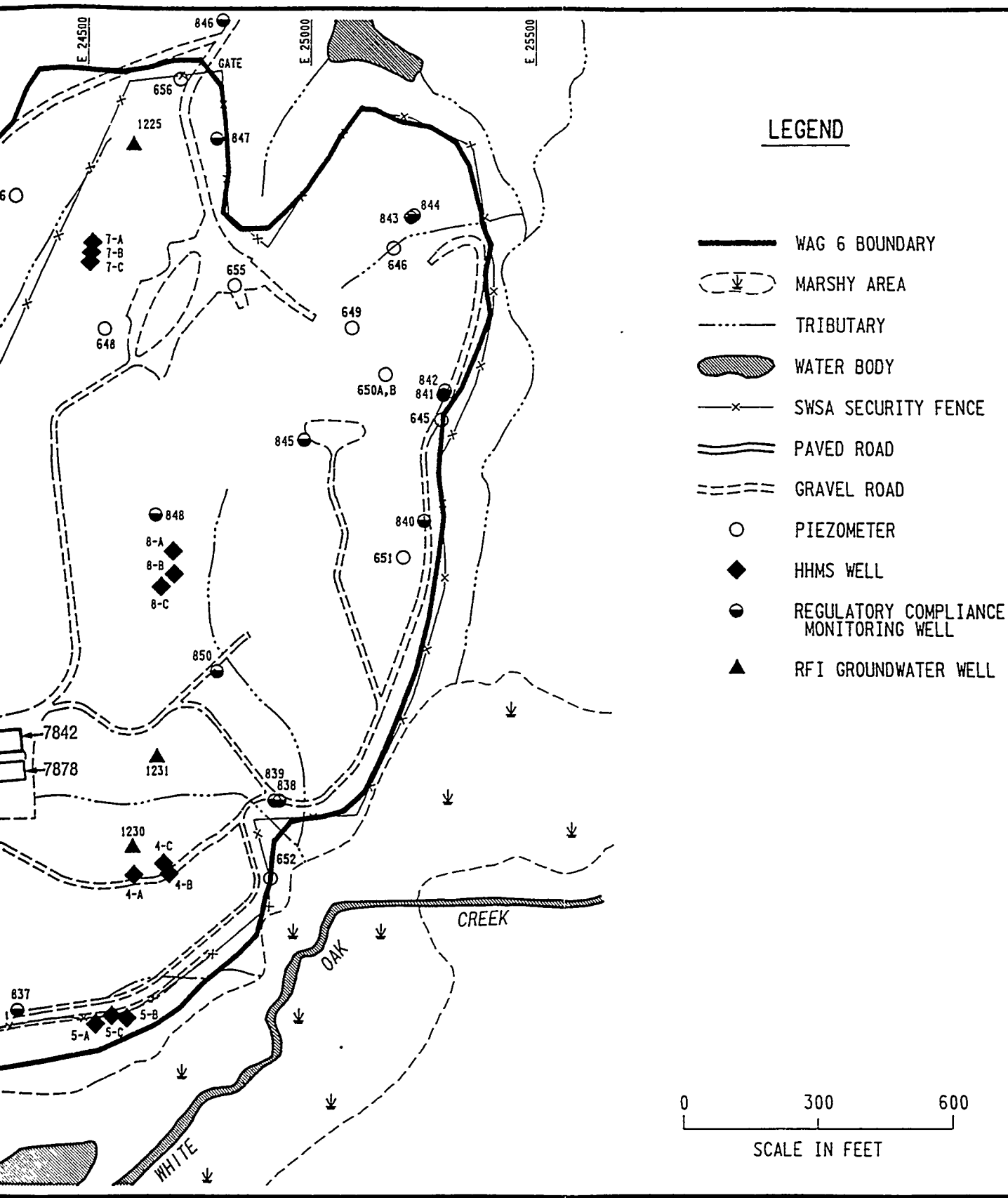


FIGURE 4-14
LOCATIONS OF KNOWN
GROUNDWATER WELLS IN WAG 6

sampled during high and low water table periods and during storm events. These wells were screened from the bedrock surface upwards from 5 to 15 ft.

The hydraulic head monitoring wells will also yield meaningful data at WAG 6. These wells are grouped in four clusters. These clusters, each consisting of three adjacent wells, were installed to provide data to establish vertical hydraulic gradients between the water table and deeper zones in bedrock.

The wells in the clusters were placed at depths of approximately 80, 200, and 400 ft, respectively. The objectives of the HHMS program are defined by Dreier and Toran (1989). Principal objectives are to provide data for evaluating both the transition between shallow and deep ground water system(s) and the nature of the deep system(s). It is expected that results of this study will define the lower boundary of the uppermost aquifer and identify potential pathways for on-site and off-site contaminant migration from WAG 6 through shallow, intermediate, and deep groundwater.

Recent water quality sampling and analysis has addressed both trench leachate and groundwater from a limited number of locations in WAG 6. Samples were collected only from wells; unsaturated zone sampling has not been feasible thus far. Laboratory analysis of samples has included standard water quality parameters, radionuclides, and EPA- and State of Tennessee-listed organic and inorganic compounds. The various studies are discussed in detail in Solomon et al. (1986a), Solomon et al. (1986b), and Solomon et al. (1987).

Field analyses of trench leachate and groundwater yielded similar results. Sample pH ranged from 5.7 to 8.0, with groundwater being in the neutral (slightly acidic to slightly basic) range. Alkalinity was variable, ranging from 2.5 to 14.4 mM HCO_3^- . The temperature ranged from 10.5 to 25.5°C, which are

typical values for very shallow groundwater. The samples generally showed mildly oxidizing redox conditions; however, both the Eh and dissolved oxygen (DO) values were quite variable. DO ranged from 0.1 to 8.2 mg/L and Eh ranged from -0.071 to +0.490 V. Specific conductance values ranged from 117 to 1,730 umhos/cm.

5.0 NATURE AND EXTENT OF CONTAMINATION

This section summarizes the current nature and extent of radiological, chemical, and biological contamination at WAG 6. The information presented is a combination of results from past investigations and those from the WAG 6 RFI Phase 1, Activity 1. Upon completion of Phase 1, Activity 2 of the RFI, the information presented in this section will be revised .

This section is comprised of four parts: Section 5.1, Radiological Contamination; Section 5.2, Chemical Contamination; Section 5.3, Biological Contamination; and Section 5.4, Summary of Nature and Extent of Contamination. The discussion identifies the areal extent of contamination and the maximum levels detected. Seasonal variations in the rates of contaminant migration and the effect of installation of the SWSA 6 Interim Corrective Measure are not analyzed. Such analyses, to the extent they are appropriate, will be conducted after the dry season (late summer, early fall) surface water and groundwater baseflow and stormflow data have been validated. Results will be presented in the RFI report.

A large number of radionuclides and chemicals were detected at WAG 6. The discussion in this section focuses primarily on those constituents detected at levels approaching or exceeding human health criteria. These criteria, identified in Section 7.0, provide a preliminary indication of the significance of the contaminants detected at WAG 6. This comparison is not a substitute for a site-specific risk assessment; a risk assessment is presently being developed, and will be presented in the RFI report. Appendix B presents a discussion of all radionuclides and chemicals detected at WAG 6, regardless of their levels, with respect to human health criteria.

The nature and extent of contamination described in this section represents current conditions only. In the coming years,

release rates will likely increase or decrease unpredictably for different contaminants in different areas of the SWSA. These variations (i.e., nonseasonal variations) would correspond to the unpredictable rates at which various types of waste packaging deteriorate. Based on ORNL experience at SWSA 4, it may be anticipated that, in cumulative terms, WAG 6 environmental contamination will continue to increase in the near term. In the very long term, however (i.e., hundreds of years), radioactive decay, chemical decomposition, and contaminant transport will result in lowered contamination levels.

5.1 RADIOLOGICAL CONTAMINATION

Tables 5-1 through 5-6 list radioactive isotopes detected at WAG 6. For each isotope, the tables show the range of concentrations detected in each of the human health media sampled and the respective human health criteria where available. The ranges shown in Tables 5-1 through 5-4 are based on the Phase 1, Activity 1 and ORNL SWSA 6 RCRA Groundwater Quality Assessment data (ORNL, 1989 a,b) RFI data, for groundwater, and Phase 1, Activity 1 data for surface water, subsurface soils, and surface soils, respectively, available at the time of this report. Tables 5-5 and 5-6 are based on data from previous and other ongoing investigations. Table 5-5 shows results for trench leachate, groundwater, and surface water samples; and Table 5-6 shows results for soils and sediment samples. The human health criteria listed in the tables are identified in Section 7.0.

Background data for naturally occurring radionuclides at ORNL are not yet available for inclusion in the analysis of levels of radionuclides detected at WAG 6. Site-specific background samples have recently been collected, and the data will be presented in the RFI report. Background data will be compared with WAG 6 data for radionuclides to determine if any WAG 6 levels are elevated.

TABLE 5-1
COMPARISON OF RFI GROUNDWATER DATA FOR
RADIONUCLIDES WITH HEALTH BASED CRITERIA

CAS Number	Isotope	Concentration Range (pCi/L)	Number of Locations in Which Detected ^(a)	Number of Samples in Which Detected	Health Based Criteria ^b (pCi/L)	Reference
10028-17-8	Tritium	0.11 - 4,324,320	34	95	20,000	SDWA MCL and TENN MCL ^(c)
10098-97-2	Strontium-90	0.027 - 3,027	25	63	8	SDWA MCL and TENN MCL ^(c)
	Radium - Total	0.027 - 6.22	27	69	5 ^(d)	SDWA MCL and TENN MCL ^(c) ; 40 CFR 191, 192
10198-40-0	Cobalt-60	0.27 - 324.3	29	56		
10045-97-3	Cesium-137	0.27 - 21.0	25	50		
14596-10-2	Americium-241	1.3 - 1.54	2	2		
14274-82-9	Thorium-228	1.14 - 7.30	6	7		
14269-63-7	Thorium-230	1.08 - 4.32	5	5		
7440-29-1	Thorium-232	1.08 - 5.4	5	5		
13966-29-5	Uranium-234	0.81 - 2.7	5	7	30 ^(e)	40 CFR 192, FR 52(185):36000- 36008 (September 24, 1987)
7440-61-1	Uranium-238	0.81 - 1.9	4	6	30 ^(e)	40 CFR 192, FR 52(185):36000- 36008 (September 24, 1987)
13233-32-4	Radium-224 ^(f)	11.35	1	1		
15262-20-1	Radium-226 ^(f)	1.3 - 82.7	2	2		
13966-00-2	Potassium-40	124.3 - 251.3	2	2		

(a) Thirty-five wells total.

(b) The development of health criteria is discussed in Section 7.0.

(c) Tennessee Drinking Water Standards, Chapter 1200-5-1 of the rules of the TDHE, Amended November 10, 1988.

(d) Radium-226 and Radium-228 combined (does not include Radium-224).

(e) For Uranium-234 and Uranium-238 combined.

(f) The samples for which Radium-224, -226, and -228 are reported are not the same samples for which total radium is reported.

TABLE 5-2

COMPARISON OF RFI SURFACE WATER DATA FOR
RADIONUCLIDES WITH HEALTH BASED CRITERIA

CAS Number	Isotope	Concentration Range (pCi/L)	Number of Locations in Which Detected (a)	Number of Samples in Which Detected	Health Based Criteria (pCi/L) (b)	Reference
10028-17-8	Tritium	195 - 12,000,000	15	31	20,000	SDWA MCL and TENN MCL (c)
10098-97-2	Strontium-90	6 - 9,070	7	10	8	SDWA MCL and TENN MCL (c)
10045-97-3	Cesium-137	8.4 - 195	3	4		
10198-40-0	Cobalt-60	195 - 550	1	2		
14596-10-2	Americium-241	1	1	1		
13981-16-3	Plutonium-238	1	1	1		
0-013	Plutonium-239/240	1 - 1.1	2	2		
14274-82-9	Thorium-228	1	1	1		
14269-63-7	Thorium-230	1	1	1		
7440-29-1	Thorium-232	1	1	1		
13966-29-5	Uranium-234	1	1	1	30 (d)	40 CFR 192, FR 52(185):36000-36008 (September 24, 1987)
15117-96-1	Uranium-235	1	1	1		
7440-61-1	Uranium-238	1	1	1	30 (d)	40 CFR 192, FR 52(185):36000-36008 (September 24, 1987)

(a) Fifteen surface water locations total.

(b) The development of health criteria is discussed in Section 7.0.

(c) Tennessee Drinking Water Standards, Chapter 1200-5-1 of the rules of the TDHE, Amended November 10, 1988.

(d) For Uranium-234 and Uranium-238 combined.

TABLE 5-3

COMPARISON OF RFI SUBSURFACE SOIL DATA FOR
RADIONUCLIDES WITH HEALTH BASED CRITERIA

CAS Number	Isotope	Concentration Range (pCi/g)	Number of Locations in Which Detected ^(a)	Number of Samples in Which Detected	Health Based Criteria ^b (pCi/g)	Reference
13966-00-2	Potassium-40 ^(c)	18.1 - 39.2	37	55		
10198-40-0	Cobalt-60	0.06 - 7.96	3	3		
10045-97-3	Cesium-137	0.14 - 0.4	5	9		
13233-32-4	Radium-224 ^(c)	1.11 - 1.83	37	55		
13982-63-3	Radium-226 ^(c)	<0.03 - 0.91	36	54	5 ^(d) 15 ^(e)	40 CFR 192
15262-20-1	Radium-228 ^(c)	<0.05 - 1.81	36	54		
14274-82-9	Thorium-228 ^(c)	<0.6 - 2.69	36	54		
14269-63-7	Thorium-230 ^(c)	0.56 - 1.37	24	41		
7440-29-1	Thorium-232 ^(c)	0.15 - 1.54	35	53		
15065-10-8	Thorium-234 ^(c)	0.33 - 1.36	30	47		
13966-29-5	Uranium-234 ^(c)	0.45 - 1.07	20	36		
7440-61-1	Uranium-238 ^(c)	0.6 - 0.95	3	3		
10098-97-2	Strontium-90	<0.5 - 1.1	1	1		

(a) Thirty-seven soil sample locations total.

(b) The development of health criteria is explained in Section 7.0.

(c) Naturally occurring isotopes.

(d) Averaged over first 15 cm below the surface.

(e) Averaged over 15-cm thick layers more than 15 cm below the surface.

TABLE 5-4
COMPARISON OF RFI SURFACE SOIL DATA FOR
RADIONUCLIDES WITH HEALTH BASED CRITERIA

CAS Number	Isotope	Concentration Range (pCi/g)	Number of Locations in which Detected (a)	Health Based Criteria (pCi/g) (b)	Reference
13966-00-2	Potassium-40 (c)	200-720	4		
10198-40-0	Cobalt-60	<3-170	4		
10045-97-3	Cesium-137	5.6-600000	4		
13966-29-5	Uranium-234 (c)	11-590	4		
15117-96-1	Uranium-235 (c)	<18-1.3	4		
7440-61-1	Uranium-238 (c)	4.8-110	4		
10098-97-2	Strontium-total	880-57000	4		

(a) Total number of locations is four.

(b) The development of health criteria is discussed in Section 7.0.

(c) Naturally occurring isotope.

TABLE 5-5

COMPARISON OF TRENCH LEACHATE, AND GROUNDWATER RADIONUCLIDE DATA
FROM PREVIOUS INVESTIGATIONS WITH HUMAN HEALTH CRITERIA

Media	Isotope				
	Cobalt-60	Strontium-90	Cesium-137	Total Strontium	Tritium
Health Criteria (pCi/L)(h)					Carbon-14
		8(j)		20,000(i)	
Trench Leachate, Yamura, et al. (1980)					
Range (pCi/L)	110-3,110	1,330-887,000	160-4,010	--(a)	**
Number of Locations in which Detected(b)	3	26	7		
Trench Leachate, Solomon et al. (1988)					
Range (pCi/L)	5.94-37.8	7-97300	7.84-3784	--	8,378-9,190,000
Number of Locations in which Detected(c)	5	4	7		8
Groundwater, Solomon et al. (1988)					
Range (pCi/L)	<3-23.5	** (d)	**	--	405-70,200
Number of Locations in which Detected(e)	1				5
Groundwater, Boegly (1984)					
Range (pCi/L)	2-14.9	5-5,135	1.4-230	--	562-39,000
Number of Locations in which Detected(f)	5	7	9	--	7
Surface Water, ICM Monitoring					
Range (pCi/L)	.1-1.6	--	.02-1.0	.049-12	49-150,000
Number of Locations in which Detected(g)	9		8	13	13

(a) "---" = not analyzed.

(b) Total number of locations is 26.

(c) Total number of locations is eight.

(d) "*****" = not detected.

(e) Total number of locations is five.

(f) Total number of locations is 14.

(g) Total number of locations is 13.

(h) The development of health criteria is explained in Section 7.0.

(i) Tennessee Drinking Water Standards, Chapter 1200-5-1 of the rules of the TDHE, amended November 10, 1988.

(j) Reference found in SDWA MCL and TENN MCL, 40 CFR 191, 192.

TABLE 5-6

COMPARISON OF SEDIMENT AND SOIL RADIONUCLIDE DATA FROM
PREVIOUS INVESTIGATIONS WITH HUMAN HEALTH CRITERIA

	Cobalt-60	Strontium-90	Cesium-137	Strontium Total	Potassium-40
Health Criteria ^(a)	NA ^(b)	NA	NA	NA	NA
<u>Sediment-Cerling and Spalding, 1981</u>					
Range, pCi/g	** ^(c)	.3 - 100	.09 - 5	-- ^(d)	--
Number of Locations in which Detected ^(e)	0	21	19	--	--
<u>Sediment-ICM Monitoring</u>					
Range, pCi/g	.005 - 51.3	--	.06 - 567	.06 - 116	6.5 - 23.5
Number of Locations in which Detected ^(f)	16	--	18	18	18
<u>Soil-Davis et al, 1989</u>					
Range, pCi/g	**	27 - 41.5	2.2 - 12.7	--	--
Number of Locations in which Detected ^(g)	0	3	3	--	--

(a) The identification of health criteria is explained in Section 7.0.

(b) NA = Not available

(c) "—" = Not detected

(d) "—" = Not analyzed

(e) Total number of locations is twenty-one.

(f) Total number of locations is eighteen.

(g) Total number of locations is ten.

Radionuclides detected at WAG 6 (and listed in the above tables) can be generally classified as either man-made radionuclides or naturally occurring radionuclides. Man-made radionuclides detected at WAG 6 include tritium, cobalt-60, Strontium-90-90, cesium-137, and transuranics (americium-241, plutonium-238, and plutonium-239/240). Naturally occurring radionuclides detected at WAG-6 include potassium-40 and radionuclides belonging to the uranium series (uranium-238, thorium-234, uranium-234, thorium 230, radium-226), the thorium series (thorium-232, radium-228, thorium-228, and radium-224), and the actinium series (uranium-235).

Each of the above radionuclides or categories of radionuclides is discussed in the subsections below, following a brief discussion of source areas of radioactive isotopes in Subsection 5.1.1.

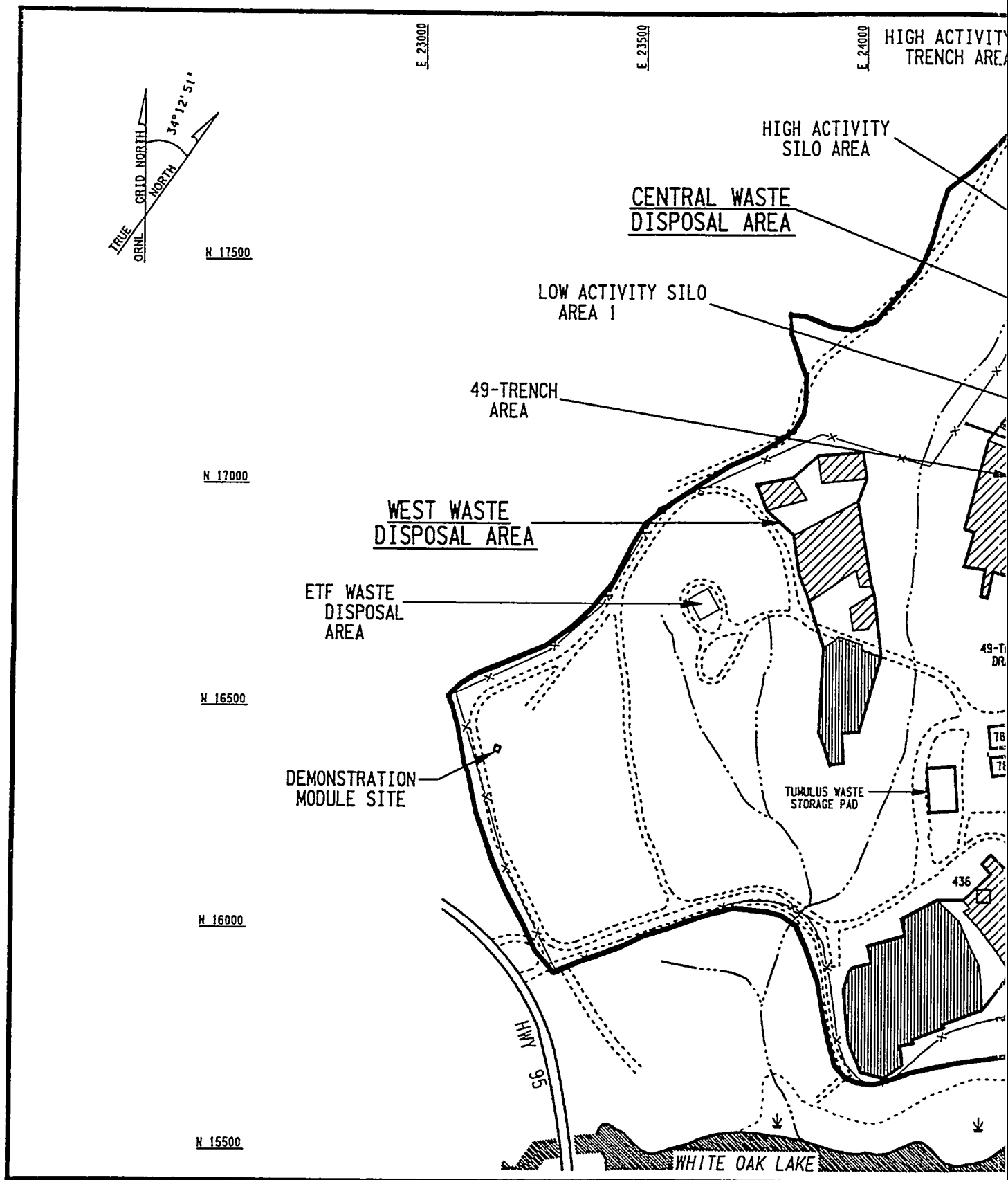
Figure 5-1 presents WAG 6 waste disposal areas. Figures 5-2 through 5-8 present the maximum activities detected of tritium, cobalt-60, total Strontium-90 and cesium-137. To aid the reader in interpretation, the sample location symbols are sized according to the relative activities of the radionuclides. Arrows are also shown which indicate the general direction of potential contaminant migration. These arrows are meant to show where there is some evidence of migration or the potential for migration and the general direction of migration expected. They do not show the precise direction or magnitude of contaminant migration nor do they necessarily indicate that a complete pathway (i.e. trench leachate to groundwater to surface water) has been observed. The arrows are located assuming gradient dominated flow. Note that for cobalt-60, total Strontium-90, and cesium-137, the trench leachate, groundwater and surface water data are presented on one figure and the soil and sediment data are presented on another figure for each analyte. The arrows are the same on both figures for each analyte. Source areas and migration pathways will be refined during the remainder of the RFI process.

Although the maximum concentrations seem to be lowest in trench leachate, intermediate in groundwater, and highest in surface water (a contradiction of logic) in the following discussions, this may be an artifact of the data presentation method. Since only the maximum concentration detected of a radionuclide is reported, and the data come from several sampling events, pathway relationships may be implied that do not actually exist. Careful examination of data from each sampling event along with information regarding surface drainage and hydrogeology will be performed to assess pathway relationships and the results will be presented in the RFI report.

5.1.1 Source Information

The ORNL waste disposal log documents the radionuclide contents of each disposal trench and auger hole; however, the activities entered into the log only represent estimated values. Figure 5-1 illustrates the major auger hole areas and specifically identifies 7 trenches and 19 auger holes that contain approximately 90 percent of the site activity (Davis et al., 1987). Figure 5-1 also labels waste disposal areas within WAG 6.

Past environmental sampling to aid in characterization of source areas has been limited primarily to sampling of trench leachates. Tamura et al. (1980) sampled leachate from 26 trenches and analyzed the leachate for cobalt-60, Strontium-90-90, and cesium-137. Solomon et al. (1988) sampled leachate from eight trenches and analyzed the samples for tritium as well as cobalt-60, Strontium-90-90, and cesium-137. Several other studies have involved radiological analyses of trench leachate, primarily for gross alpha and gross beta. The trench leachate data collected by Solomon et al. (1988) showed large and erratic changes in radionuclide concentrations with changing hydraulic conditions. Furthermore, the data indicated no correlation between the



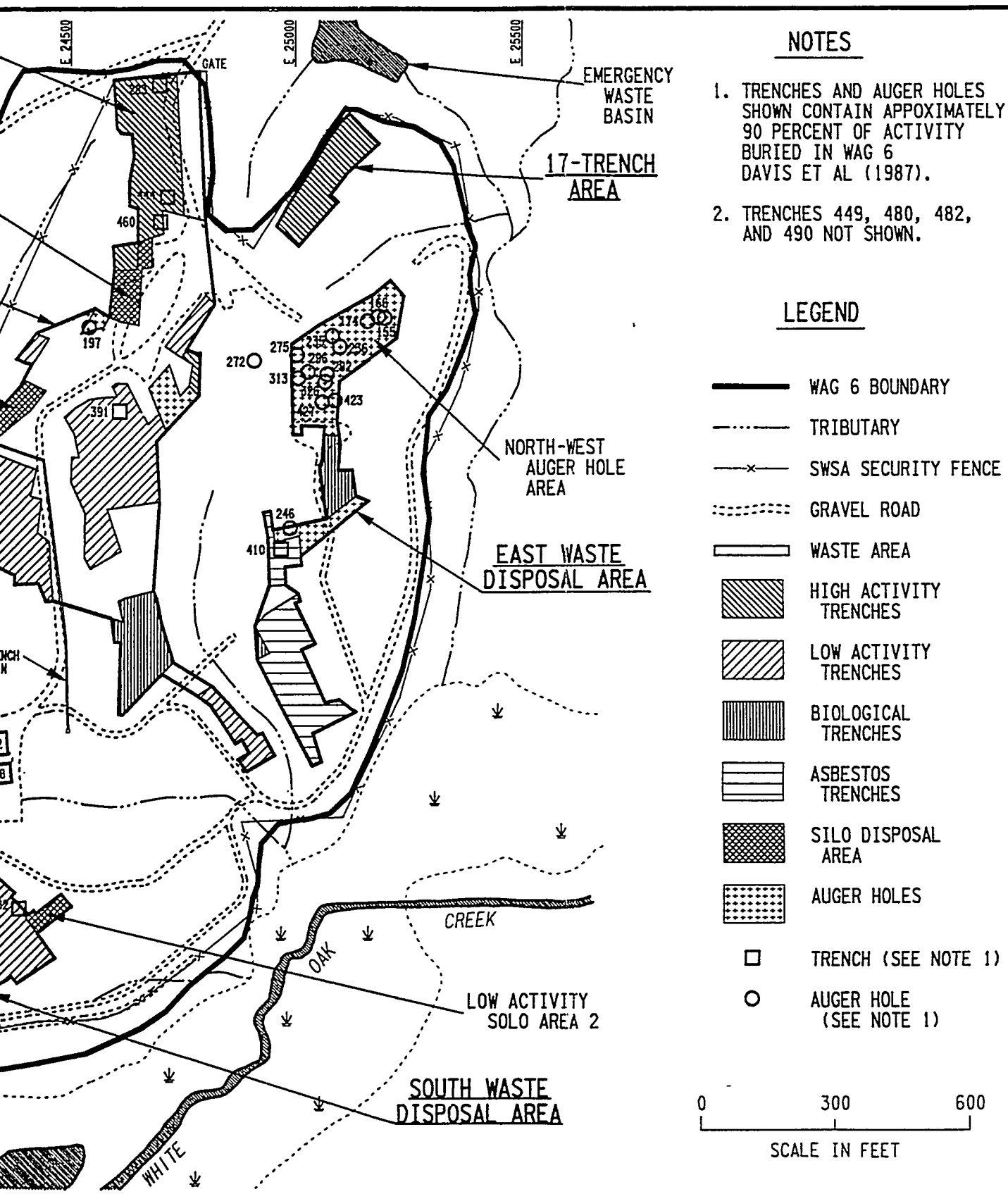


FIGURE 5-1
WAG 6 WASTE DISPOSAL AREAS

concentrations detected in trench leachates and the total activities reported for those trenches in the ORNL waste disposal log. This can most likely be attributed to the fact that waste packaging ranged from plastic trash bags to lined concrete boxes; contaminant release rates would differ vastly among package types.

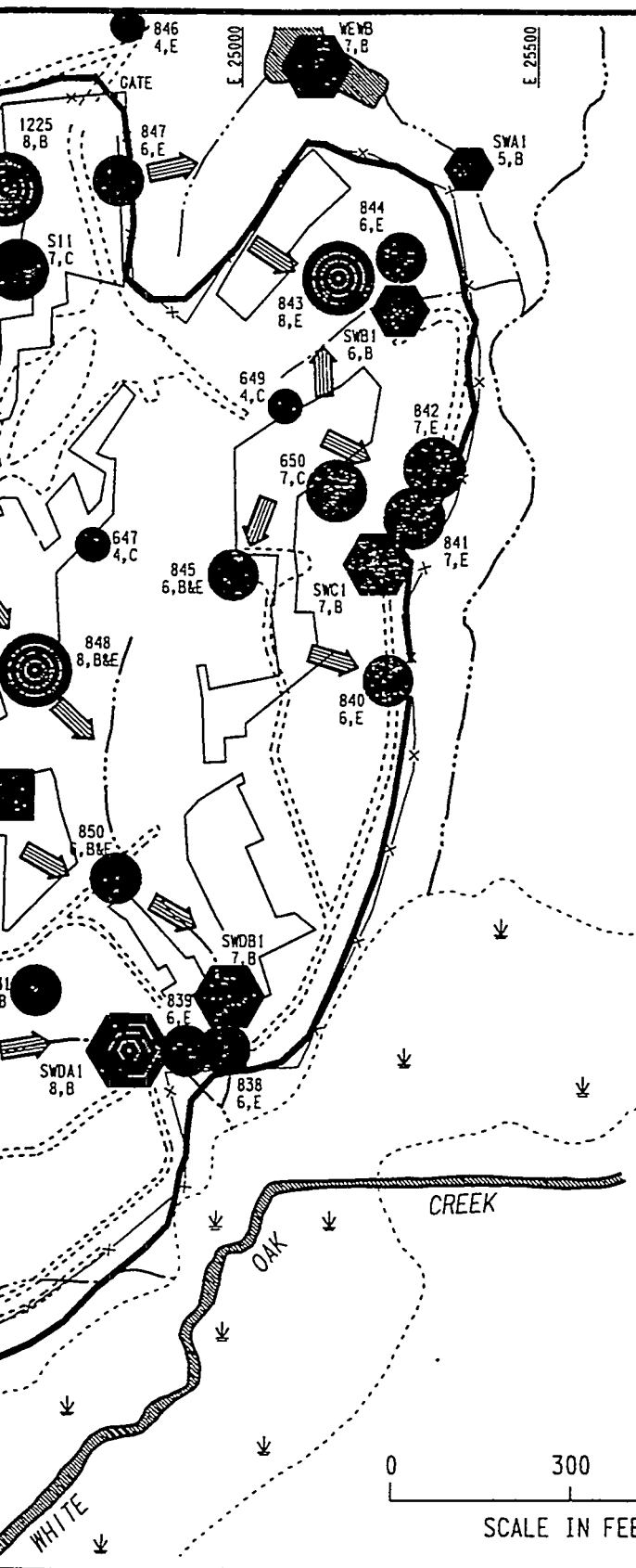
Previous trench leachate sampling results are included in the discussion of results for individual radionuclides. However, the reported concentrations should be interpreted in the light of the conclusions of Solomon et al. (1988) that any single observation could vary by several orders of magnitude depending on conditions at time of sample collection.

5.1.2 Tritium

Tritium is widely distributed in trench leachates, groundwater and surface water at levels greatly exceeding the Safe Drinking Water Act Maximum Contaminant Level (SDWA MCL) of 20,000 pCi/L. The maximum concentrations detected range from 8,380 to 4,860,000 pCi/L in trench leachates (Solomon et al., 1988), 0.86 to 4,324,000 pCi/L in groundwater and from 195 to 12 million pCi/L in surface water (the 12 million pCi/L concentration was detected at the 49-Trench drain outfall).

Figure 5-2 illustrates the maximum levels detected at individual sampling locations. The data shown indicate multiple sources that have led to contamination in drainages throughout the site. These sources include:

- o Central Waste Disposal Area
 - high-activity trench group at the north end of area
 - 49-trench area
 - low-activity trench group immediately east of the 49-trench area
 - biological trench group



NOTES

1. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
2. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE ACTIVITY OF THE SAMPLE.
3. THE RANGES OF ACTIVITY (PCI/L) INDICATED ARE AS FOLLOWS:

1 =	0.1 - 0.99
2 =	1 - 9.9
3 =	10 - 99
4 =	100 - 999
5 =	1000 - 9999
6 =	10,000 - 99,999
7 =	100,000 - 999,999
8 =	1,000,000 - 12,000,000
4. THE SOURCES OF DATA ARE AS FOLLOWS:
 - B = RFI SAMPLING
 - C = SOLOMON, et al (1988)
 - E = ORNL REGULATORY COMPLIANCE MONITORING

RESULTS

LEGEND

- WAG 6 BOUNDARY
- TRIBUTARY
- x- SWSA SECURITY FENCE
- GRAVEL ROAD
- WASTE AREA
- ← POTENTIAL CONTAMINANT MIGRATION
- T135 — SAMPLE DESIGNATION
- 3,C — RANGE OF ACTIVITY, SOURCE OF DATA
- GROUNDWATER SAMPLE
- TRENCH LEACHATE SAMPLE
- SURFACE WATER SAMPLE

FIGURE 5-2
DISTRIBUTION OF TRITIUM

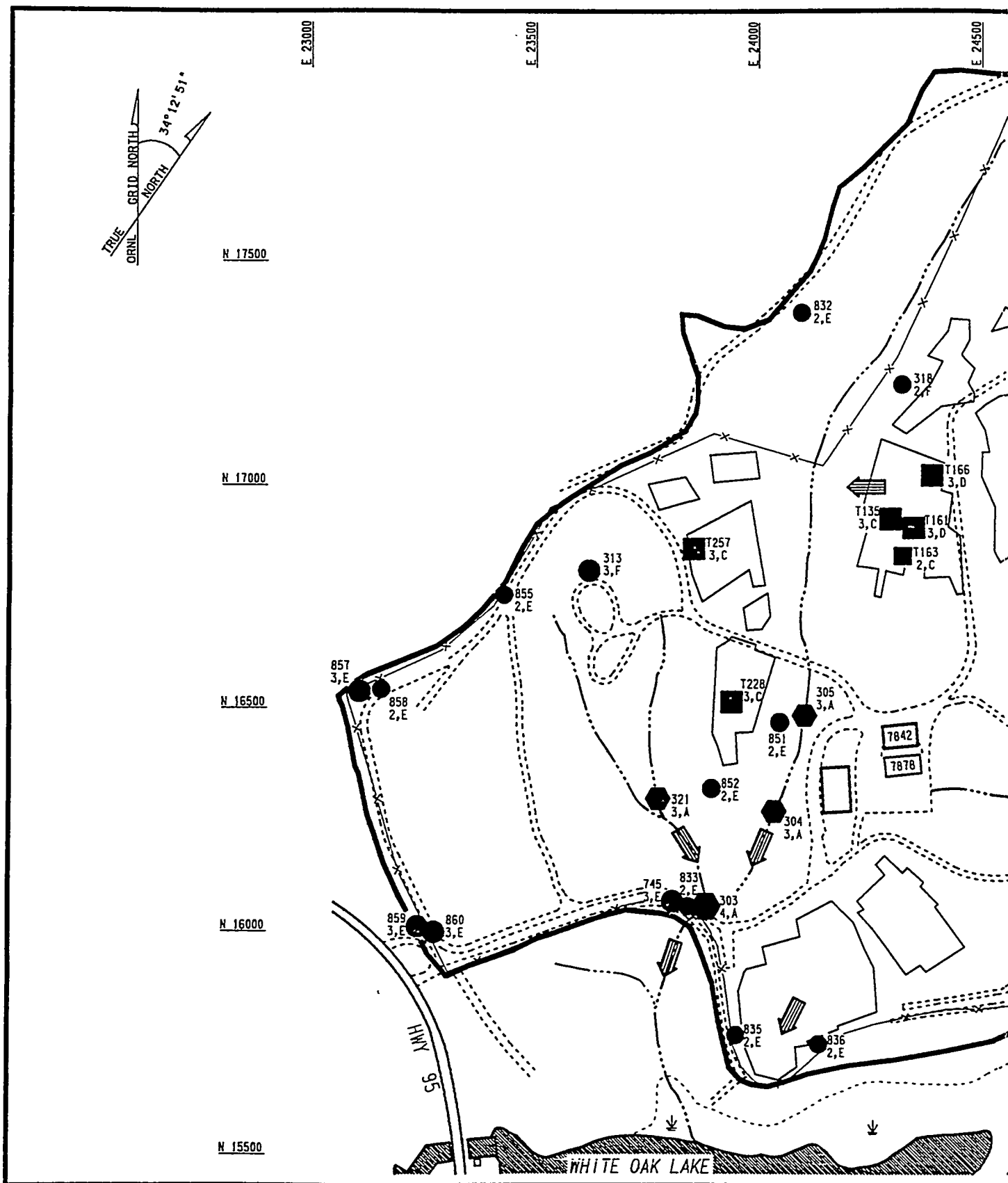
- o West Waste Disposal Area
- o East Waste Disposal Area (north-west auger hole group)
- o South Waste Disposal Area
- o 17-Trench Area

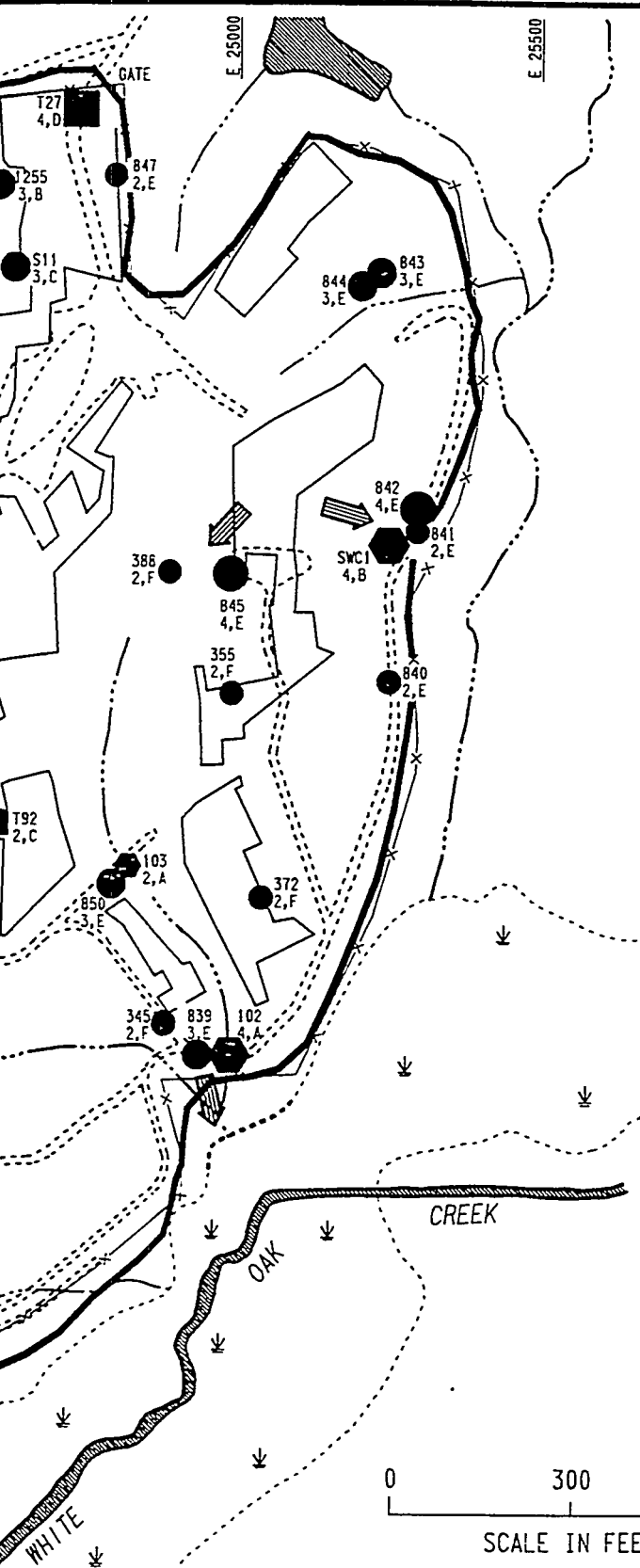
5.1.3 Cobalt-60

Cobalt-60 was detected in trench leachates, groundwater, in surface water, sediments, and soils. No human health criteria have yet been developed for cobalt-60 in water, soils, or sediments in WAG 6; therefore, a preliminary assessment of the significance of the levels detected is not possible. The maximum concentrations detected ranged from 6 to 19 pCi/L in trench leachate, from 0.27 to 324 pCi/L in groundwater, and from 195 to 550 pCi/L in surface water. The maximum levels detected in subsurface soil ranged from undetected at 0.06 pCi/g to 7.96 pCi/g, and in sediments ranged from 0.005 to 51.3 pCi/g (ICM monitoring program).

The maximum levels of cobalt-60 detected at each sampling location are illustrated for water sampling locations in Figure 5-3 and for soil and sediment sampling locations in Figure 5-4. The data shown on these figures indicate that cobalt-60 may be migrating from the following areas:

- o Central Waste Disposal Area
 - high activity trench group at the north end of the area
 - the 49-trench area
 - biological trench area
- o West Waste Disposal Area
- o East Waste Disposal Area





NOTES

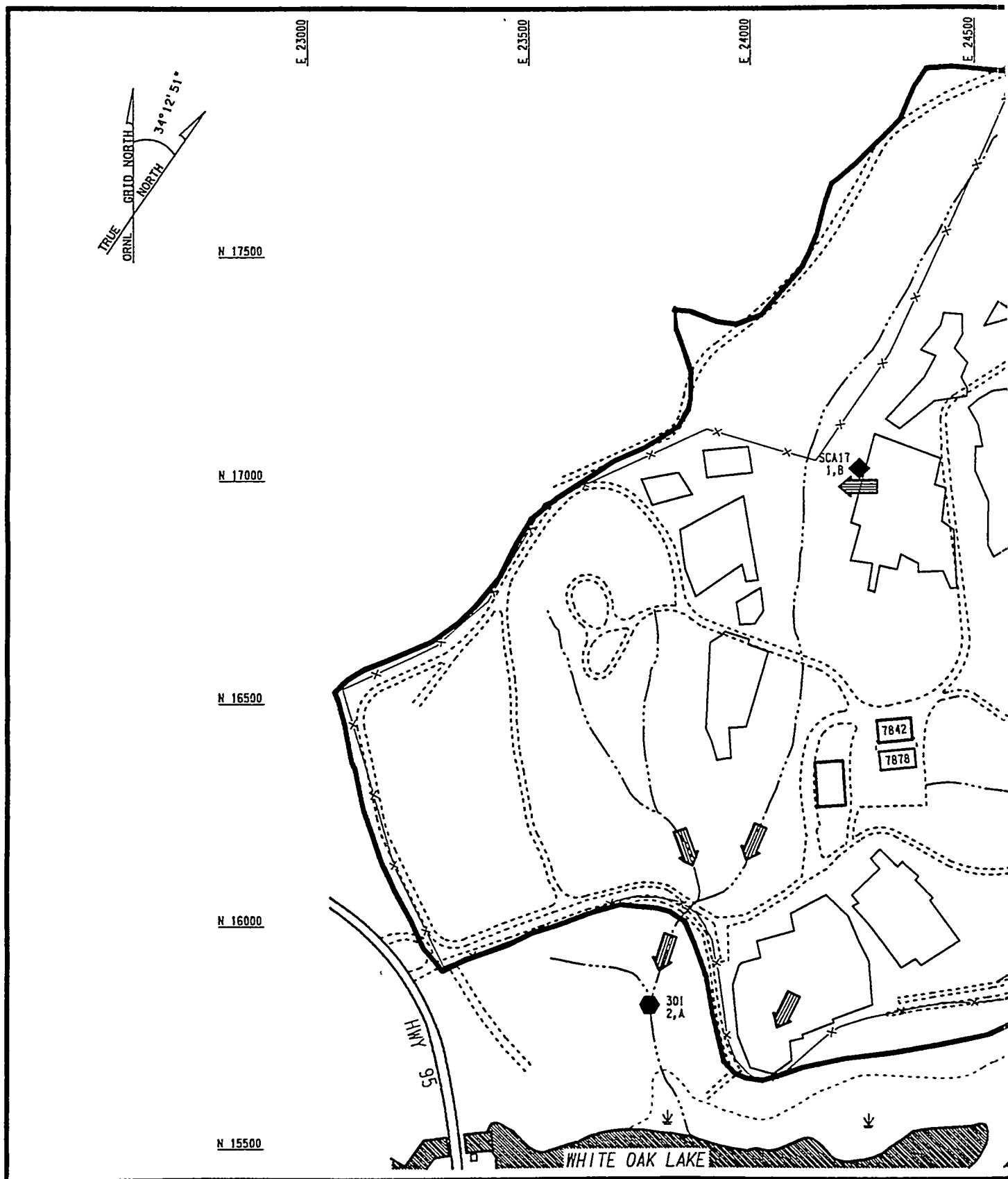
1. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
2. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE ACTIVITY OF THE SAMPLE.
3. THE RANGES OF ACTIVITY (PCI/L) INDICATED ARE AS FOLLOWS:

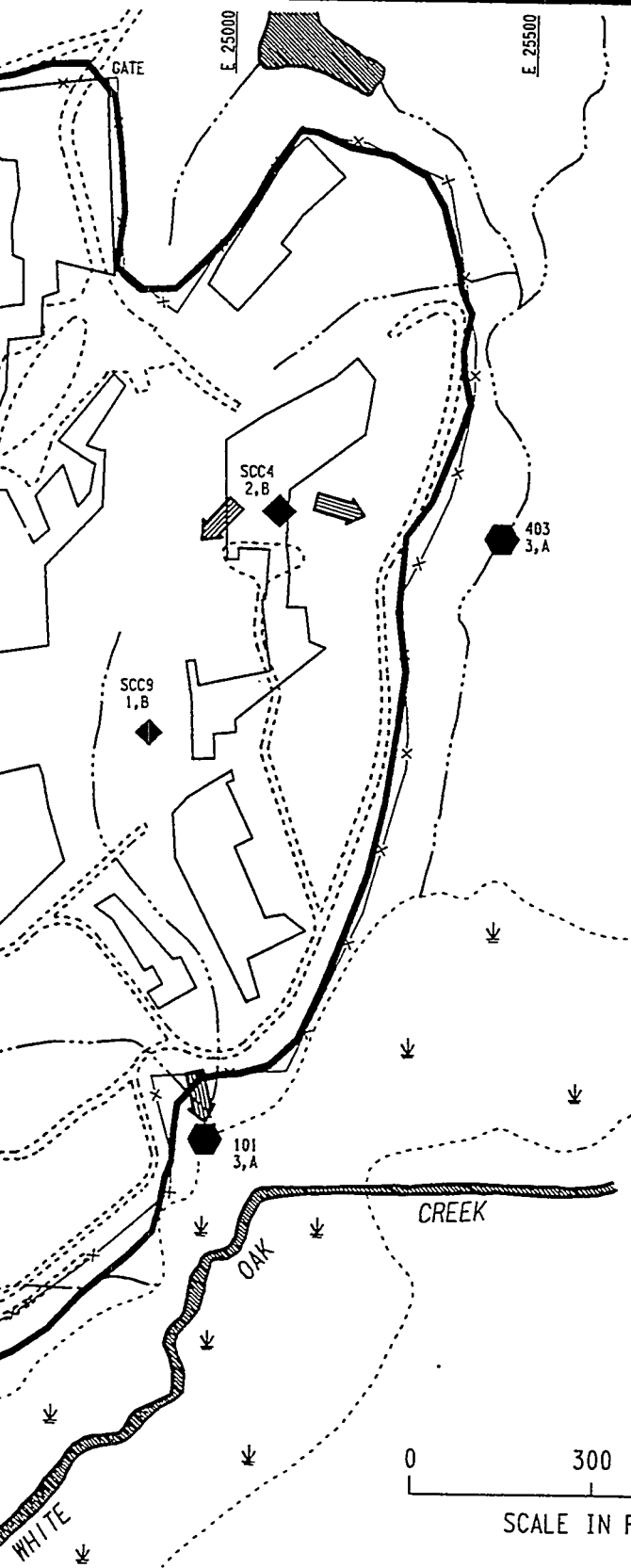
1 =	0.1 - 0.99
2 =	1 - 9.9
3 =	10 - 99
4 =	100 - 999
5 =	1000 - 9999
6 =	10,000 - 99,999
7 =	100,000 - 999,999
8 =	1,000,000 - 9,999,999
4. THE SOURCES OF DATA ARE AS FOLLOWS:
 - A = ICM SAMPLING
 - B = RFI SAMPLING
 - C = SOLOMON, et al (1988)
 - D = TAMURA, et al (1980)
 - E = ORNL REGULATORY COMPLIANCE MONITORING RESULTS
 - F = OBSERVATION WELLS FOR WHICH DATA IS REPORTED IN BOEGLY, et al (1984)

LEGEND

- WAG 6 BOUNDARY
- TRIBUTARY
- SWSA SECURITY FENCE
- GRAVEL ROAD
- WASTE AREA
- POTENTIAL CONTAMINANT MIGRATION BASED ON DATA ON FIGURES 5-3 & 5-4
- SAMPLE DESIGNATION
RANGE OF ACTIVITY,
SOURCE OF DATA
- GROUNDWATER SAMPLE
- TRENCH LEACHATE SAMPLE
- SURFACE WATER SAMPLE

FIGURE 5-3
COBALT-60 IN TRENCH
LEACHATE, GROUNDWATER, AND
SURFACE WATER





NOTES

1. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
2. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE ACTIVITY OF THE SAMPLE.
3. THE RANGES OF ACTIVITY (PCI/L) INDICATED ARE AS FOLLOWS:

1 =	0.1 - 0.99
2 =	1 - 9.9
3 =	10 - 99
4 =	100 - 999
5 =	1000 - 9999
6 =	10,000 - 99,999
7 =	100,000 - 999,999
8 =	1,000,000 - 9,999,999
4. THE SOURCES OF DATA ARE AS FOLLOWS:

A =	ICM SAMPLING
B =	RFI SAMPLING

LEGEND

- | | |
|--|--|
| | WAG 6 BOUNDARY |
| | TRIBUTARY |
| | SWSA SECURITY FENCE |
| | GRAVEL ROAD |
| | WASTE AREA |
| | POTENTIAL CONTAMINANT MIGRATION BASED ON DATA ON FIGURES 5-3 & 5-4 |
| | SAMPLE DESIGNATION
RANGE OF ACTIVITY,
SOURCE OF DATA |
| | SOIL BORING |
| | SEDIMENT SAMPLE |

FIGURE 5-4
DISTRIBUTION OF COBALT-60 IN
SOILS SEDIMENTS

5.1.4 Strontium-90

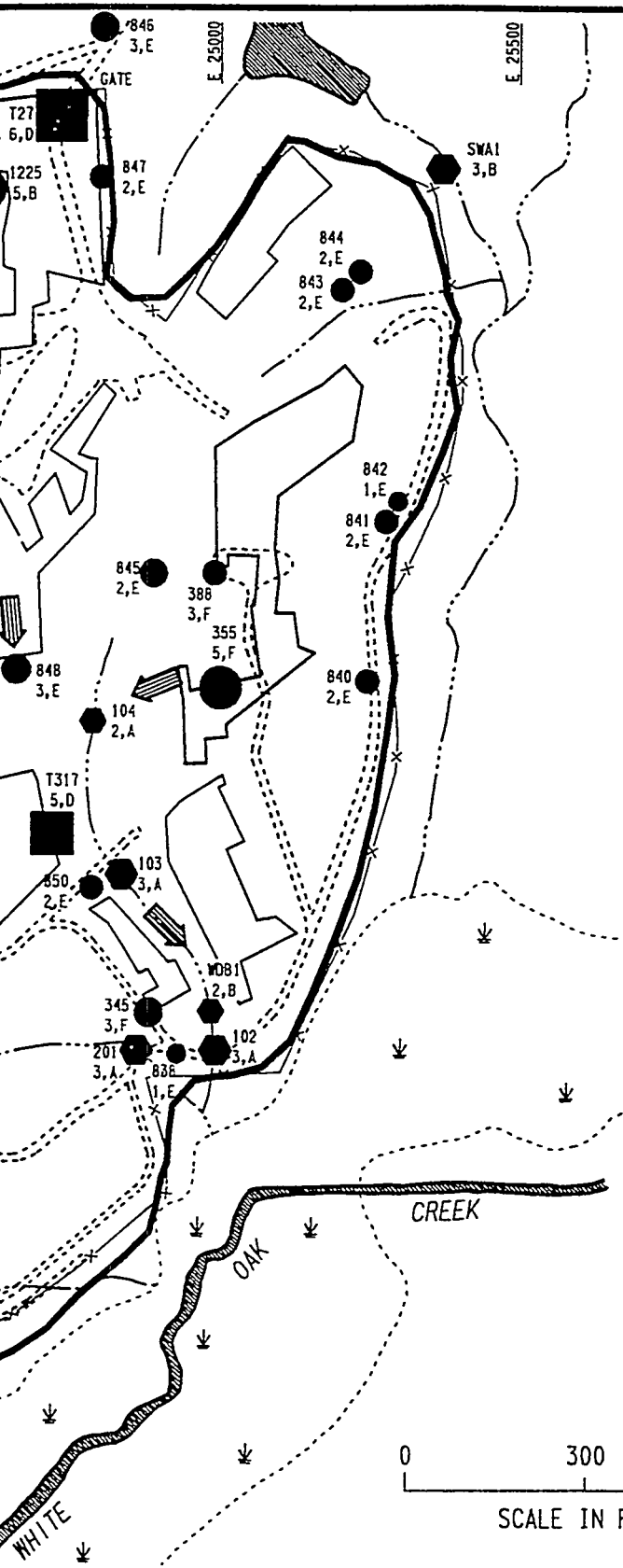
Strontium-90 was detected in trench leachates, groundwater, surface water, soils and sediments. Concentrations detected in water exceeded the SDWA MCL for strontium-90 of 8 pCi/L. The maximum levels detected ranged from 7 to 97,300 pCi/L in trench leachate (Solomon et al., 1988), from 0.03 to 3,027 pCi/L in groundwater, and from 6 to 9,070 pCi/L in surface water.

Human health criteria for strontium-90 in soils and sediments have not yet been developed for WAG 6, therefore, a preliminary assessment of the levels detected is not possible. The maximum concentrations detected in soil range from undetected at 0.5 pCi/g up to 1.1 pCi/g and in sediment ranged from 0.3 to 100 pCi/g (Cerling and Spalding, 1981).

The maximum levels detected at water sampling locations are shown in Figure 5-5; Figure 5-6 shows maximum levels for soil and sediment sampling locations.

As indicated in the figures, strontium-90 was more prevalent in samples collected along the drainage on the west side of the central waste disposal area. The potential source areas for this contamination include:

- o Central Waste Disposal Area
 - trench group at the north end of the disposal area
 - 49-trench area
 - biological trench group
 - low activity trench group to east of 49-trench area
- o West Waste Disposal Area
- o East Waste Disposal Area
- o South Waste Disposal Area



NOTES

1. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
2. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE ACTIVITY OF THE SAMPLE.
3. THE RANGES OF ACTIVITY (PCI/L) INDICATED ARE AS FOLLOWS:

1 =	0.1 - 0.99
2 =	1 - 9.9
3 =	10 - 99
4 =	100 - 999
5 =	1000 - 9999
6 =	10,000 - 99,999
7 =	100,000 - 999,999
8 =	1,000,000 - 9,999,999

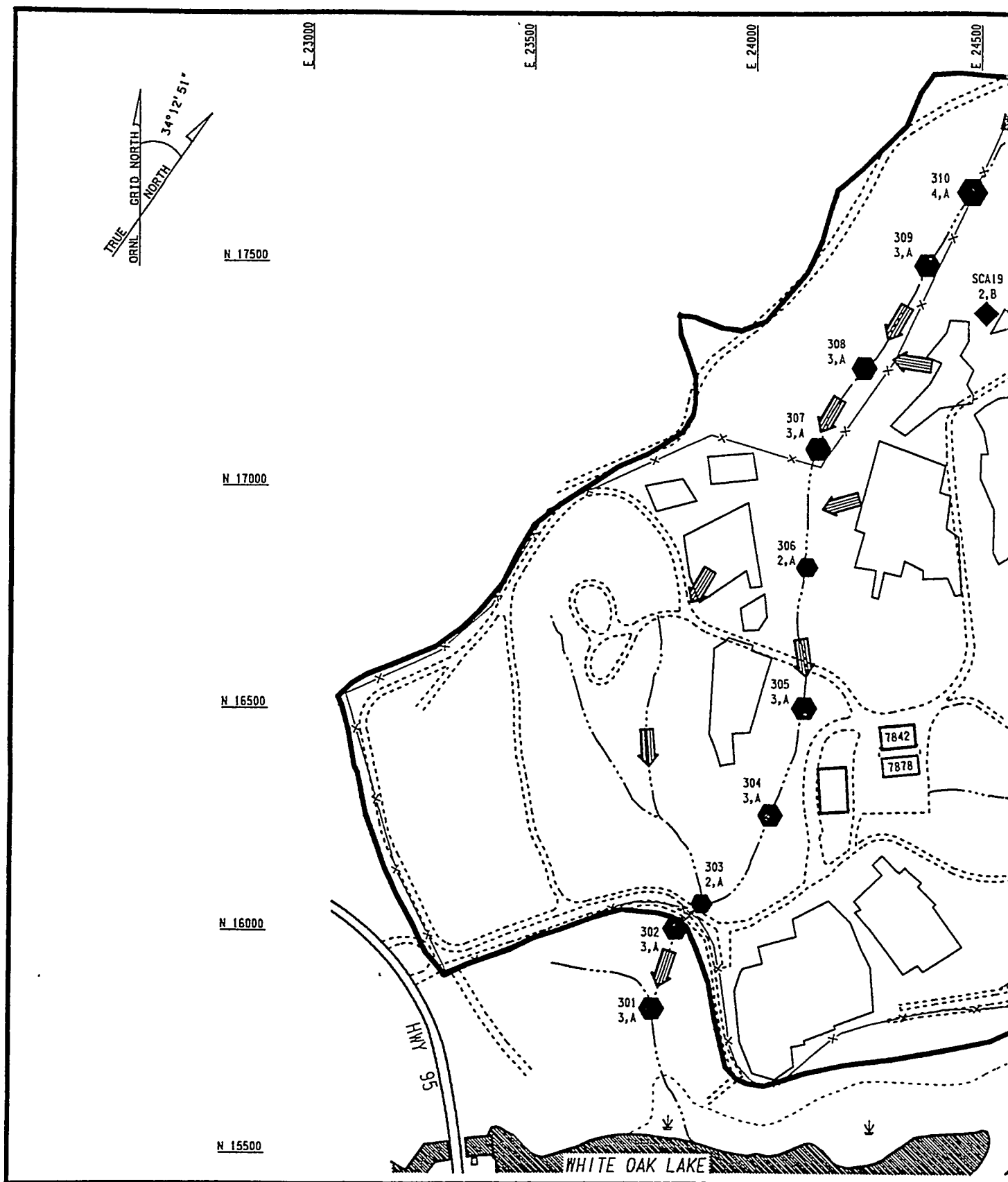
4. THE SOURCES OF DATA ARE AS FOLLOWS:

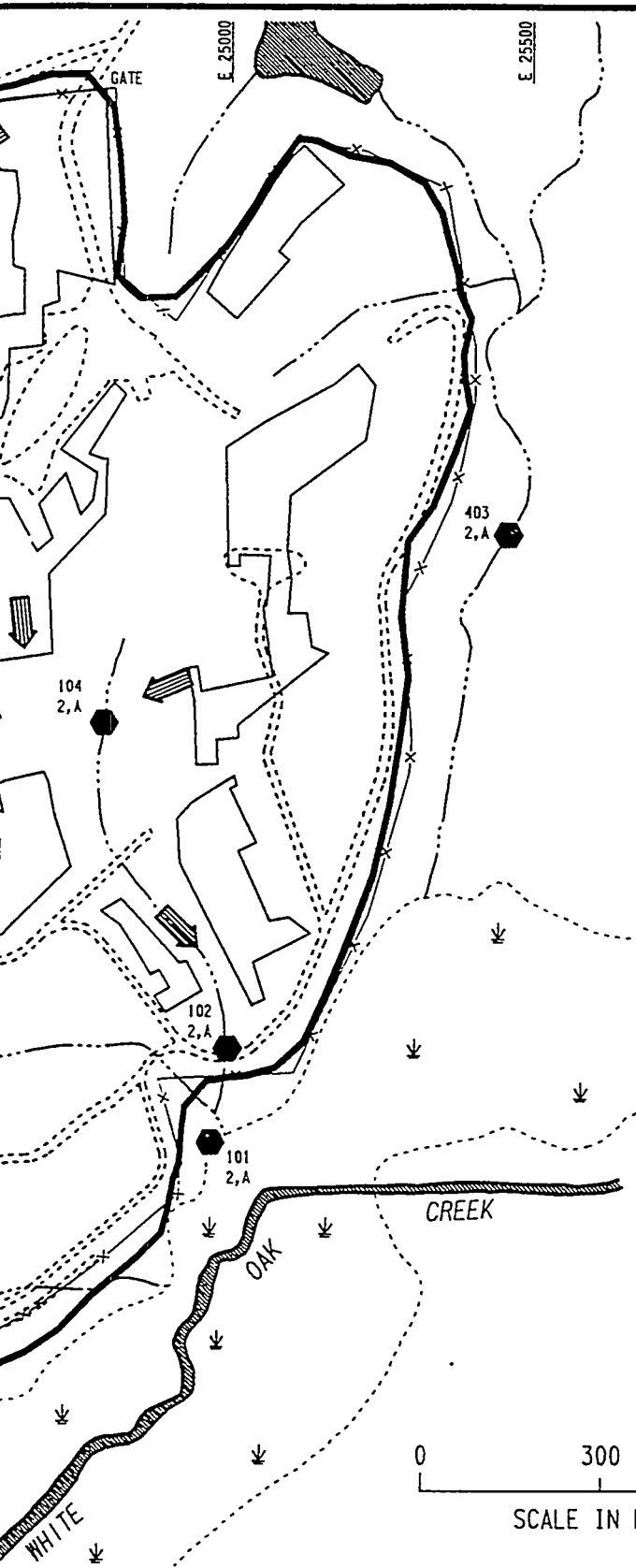
A =	ICM SAMPLING
B =	RFI SAMPLING
C =	SOLOMON, et al (1988)
D =	TAMURA, et al (1980)
E =	ORNL REGULATORY COMPLIANCE MONITORING RESULTS
F =	OBSERVATION WELLS FOR WHICH DATA IS REPORTED IN BOEGLY, et al (1984)

LEGEND

- | | |
|--|--|
| | WAG 6 BOUNDARY |
| | TRIBUTARY |
| | SWSA SECURITY FENCE |
| | GRAVEL ROAD |
| | WASTE AREA |
| | POTENTIAL CONTAMINANT MIGRATION BASED ON DATA ON FIGURES 5-5 & 5-6 |
| | SAMPLE DESIGNATION
RANGE OF ACTIVITY,
SOURCE OF DATA |
| | GROUNDWATER SAMPLE |
| | TRENCH LEACHATE SAMPLE |
| | SURFACE WATER SAMPLE |

FIGURE 5-5
DISTRIBUTION OF STRONTIUM IN
TRENCH LEACHATE, GROUNDWATER,
AND SURFACE WATER





NOTES

1. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
2. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE ACTIVITY OF THE SAMPLE.
3. THE RANGES OF ACTIVITY (PCI/L) INDICATED ARE AS FOLLOWS:

1 =	0.1 - 0.99
2 =	1 - 9.9
3 =	10 - 99
4 =	100 - 999
5 =	1000 - 9999
6 =	10,000 - 99,999
7 =	100,000 - 999,999
8 =	1,000,000 - 9,999,999
4. THE SOURCES OF DATA ARE AS FOLLOWS:

A =	ICM SAMPLING
B =	RFI SAMPLING

LEGEND

- WAG 6 BOUNDARY
- TRIBUTARY
- x SWSA SECURITY FENCE
- GRAVEL ROAD
- WASTE AREA
- ← POTENTIAL CONTAMINANT MIGRATION BASED ON DATA ON FIGURES 5-5 & 5-6
- SCA19 SAMPLE DESIGNATION
- 3,C RANGE OF ACTIVITY, SOURCE OF DATA
- SEDIMENT SAMPLE
- SOIL BORING

FIGURE 5-6
DISTRIBUTION OF STRONTIUM
IN SEDIMENTS AND SOILS

5.1.5 Cesium-137

Cesium-137 was detected in trench leachates, groundwater, surface water, soils, and sediments. The maximum concentrations detected range from 5.94 to 18.9 pCi/L in trench leachates (Solomon et al., 1988), from 0.27 to 21 pCi/L in groundwater, and from 8.4 to 195 pCi/L in surface water. The maximum concentrations detected in soil range from 0.14 to 0.4 pCi/g; maximum concentrations in sediment range from 0.06 to 567 pCi/g. No human health criteria have yet been developed for cesium-137 in water, soils, or sediments in WAG 6, so a preliminary assessment of the significance of the levels detected is not possible.

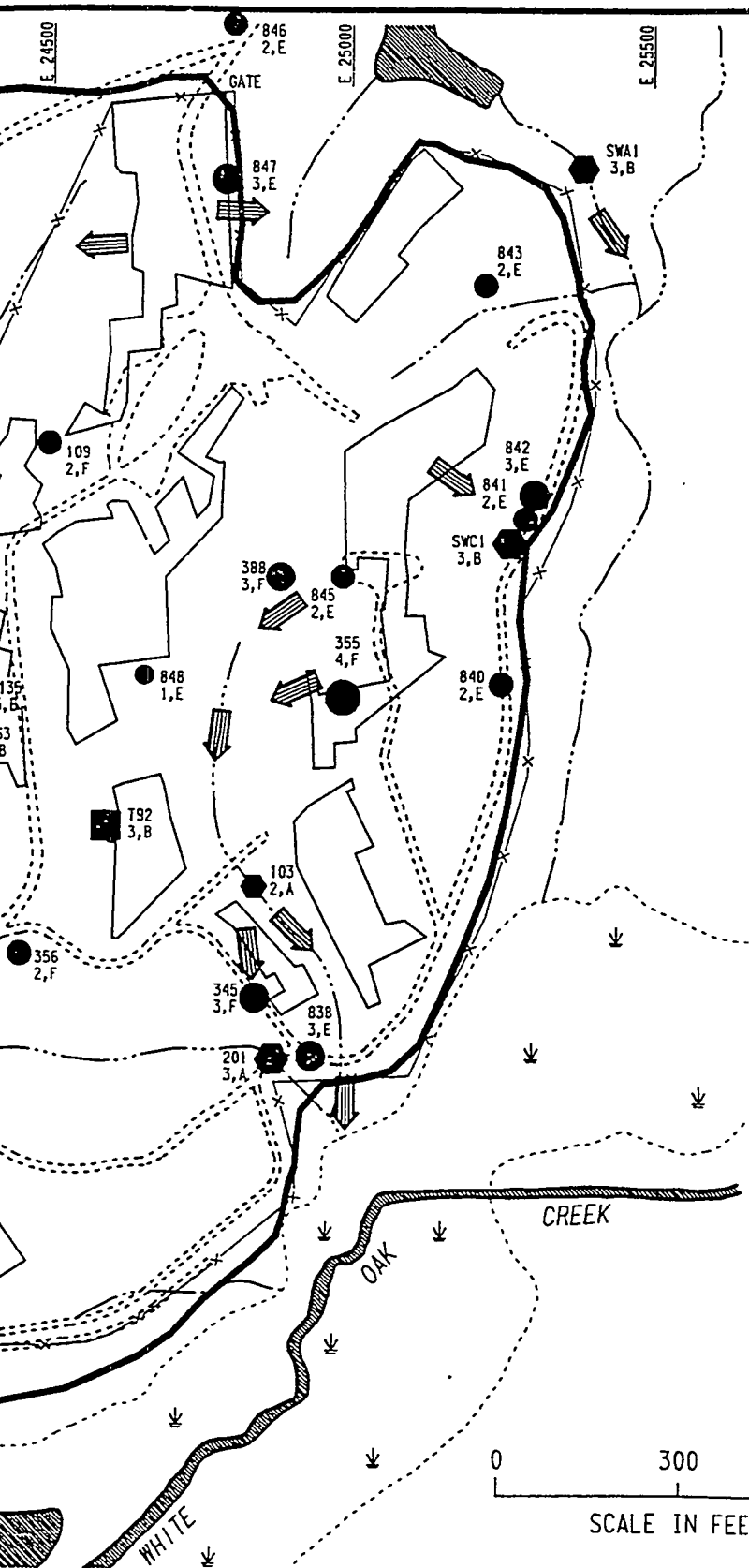
Maximum levels of cesium-137 detected for water sampling locations are illustrated in Figure 5-7 and for soil and sediment sampling locations in Figure 5-8.

As indicated in Figures 5-7 and 5-8, cesium-137 has been detected throughout the site but generally at low levels. Individual areas where cesium-137 was detected are listed below:

- o Central Waste Disposal Area
 - high activity trench group at the north end of the area
 - 49-trench area
 - biological trench area
- o West Waste Disposal Area
- o East Waste Disposal Area
- o South Waste Disposal Area

5.1.6 Transuranics

5.1.6.1 Groundwater and Surface Water. Transuranics detected in surface water and groundwater at WAG 6 during the RFI included plutonium-238, plutonium-239/240, curium-244 and americium-241.



NOTES

1. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
2. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE ACTIVITY OF THE SAMPLE.
3. THE RANGES OF ACTIVITY (PCI/L) INDICATED ARE AS FOLLOWS:

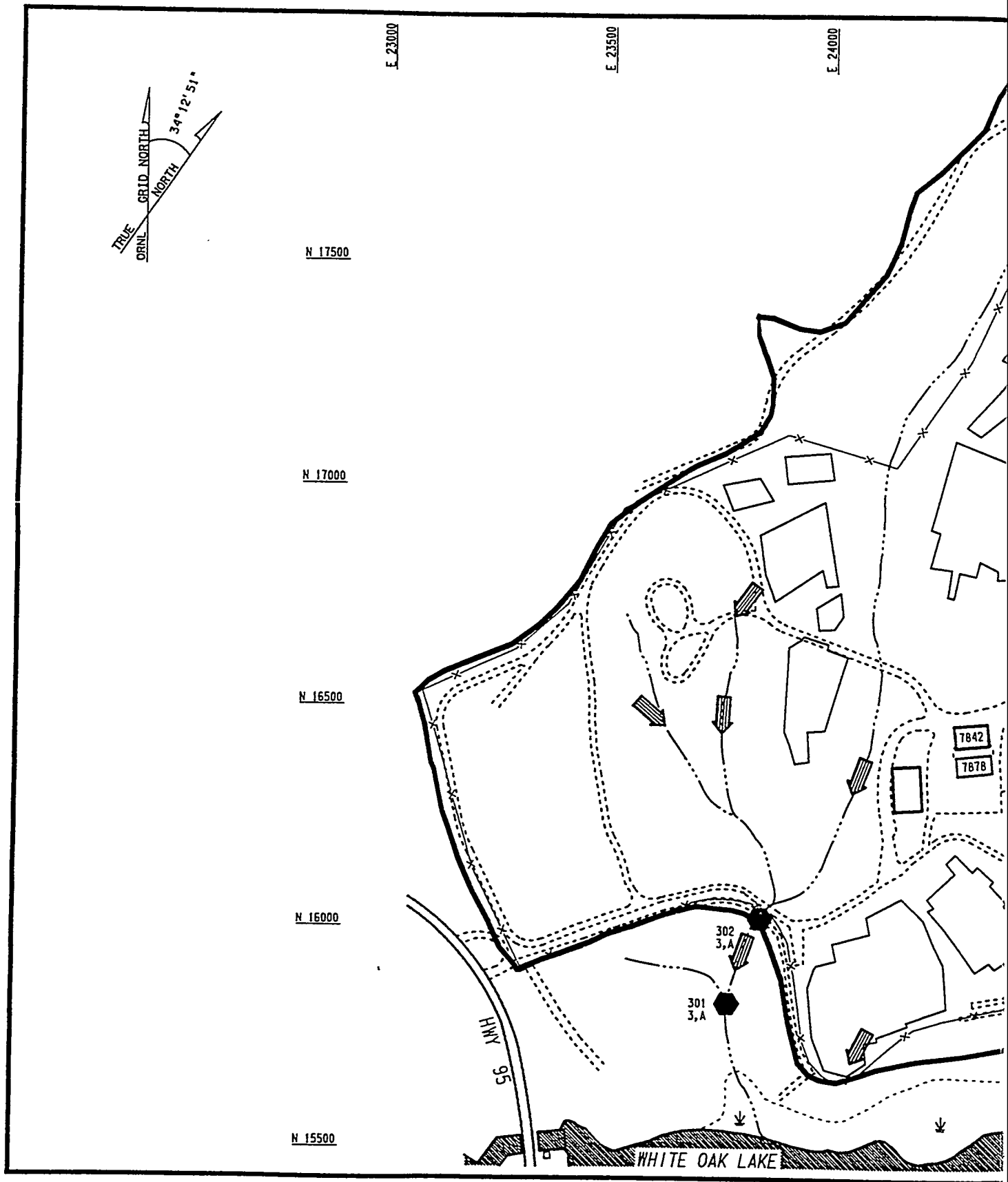
1 =	0.05 - 0.99
2 =	1 - 9.9
3 =	10 - 99
4 =	100 - 999
5 =	1000 - 9999
6 =	10,000 - 99,999
7 =	100,000 - 999,999
8 =	1,000,000 - 9,999,999
4. THE SOURCES OF DATA ARE AS FOLLOWS:

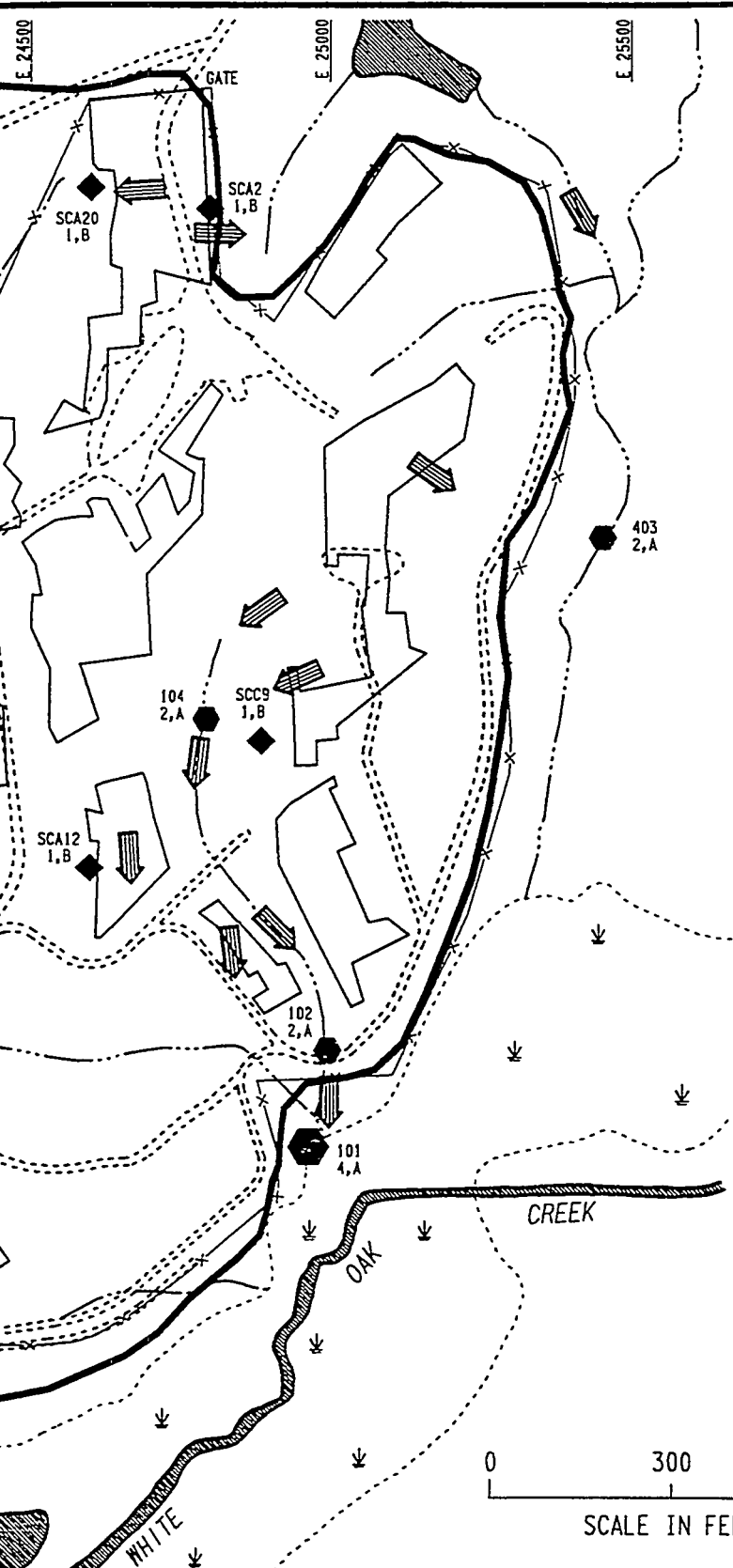
A =	ICM SAMPLING
B =	RFI SAMPLING
D =	TAMURA, et al (1980)
E =	ORNL REGULATORY COMPLIANCE MONITORING RESULTS
F =	OBSERVATION WELLS FOR WHICH DATA IS REPORTED IN BOEGLY, et al (1984)

LEGEND

- | | |
|--|--|
| | WAG 6 BOUNDARY |
| | TRIBUTARY |
| | SWSA SECURITY FENCE |
| | GRAVEL ROAD |
| | WASTE AREA |
| | POTENTIAL CONTAMINANT MIGRATION BASED ON DATA ON FIGURES 5-7 & 5-8 |
| | SAMPLE DESIGNATION
RANGE OF ACTIVITY,
SOURCE OF DATA |
| | GROUNDWATER SAMPLE |
| | TRENCH LEACHATE SAMPLE |
| | SURFACE WATER SAMPLE |

FIGURE 5-7
DISTRIBUTION OF
CS-137 IN TRENCH LEACHATE,
GROUNDWATER AND SURFACE WATER





NOTES

1. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
2. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE ACTIVITY OF THE SAMPLE.
3. THE RANGES OF ACTIVITY (PCI/L) INDICATED ARE AS FOLLOWS:

1 =	0.01 - 0.99
2 =	1 - 9.9
3 =	10 - 99
4 =	100 - 999
5 =	1000 - 9999
6 =	10,000 - 99,999
7 =	100,000 - 999,999
8 =	1,000,000 - 9,999,999
4. THE SOURCES OF DATA ARE AS FOLLOWS:

A =	ICM SAMPLING
B =	RFI SAMPLING

LEGEND

- WAG 6 BOUNDARY
- - - - - TRIBUTARY
- x - SWSA SECURITY FENCE
- . - . - GRAVEL ROAD
- ▨ WASTE AREA
- ← POTENTIAL CONTAMINANT MIGRATION BASED ON DATA ON FIGURES 5-7 & 5-8
- T135 — SAMPLE DESIGNATION
- ◆ 3,C — RANGE OF ACTIVITY, SOURCE OF DATA
- SEDIMENT SAMPLE
- ◆ SOIL BORING

FIGURE 5-8
DISTRIBUTION OF CS-137 IN
SOILS AND SEDIMENTS

Plutonium-238 and plutonium-239/240 were both detected at 1 pCi/L at surface water seep sampling location WFBB3. This station is located downslope of the high-activity trenches at the north end of the central disposal area. Plutonium-239/240 was also detected at 1.1 pCi/L at surface water sampling location WFBB2, located downstream of WFBB3. Plutonium was not detected in any other surface water samples, nor was it detected in any groundwater samples. Americium-241 was detected at one surface water sampling location and two groundwater sampling locations. It was detected at 1 pCi/L at surface water seep sampling location WFBB3. In groundwater it was detected at 1.55 pCi/L in Well 1227 (on the western perimeter of the west disposal area) and at 1.3 pCi/L in Well 1233 (on the western perimeter of the 49-trench area).

5.1.6.2 Soils. Transuranics were not detected in any subsurface soil samples collected during Phase 1, Activity 1 of the RFI; however, plutonium-238, plutonium-239, americium-241, and curium-244 were detected in several surface soil samples. These surface soil samples were collected from locations identified as "hot spots" during a radiological walkover survey; the survey was conducted prior to construction of the ICM to provide data on which to base the ES&H plan for ICM construction (BNI, 1988a). Because earthwork was conducted in these areas during ICM implementation, the data developed regarding hot spots are no longer representative. However, the data are described in Appendix B for general information.

5.1.7 Potassium-40

Potassium-40, a naturally occurring radionuclide, was detected in all soil samples and in two groundwater samples. The levels detected in soil ranged from 18.1 to 39.3 pCi/g and correspond to typical values identified in Eisenbud (1987). The levels detected in groundwater were 124 and 251 pCi/L.

5.1.8 Uranium, Thorium, and Actinium Series Radionuclides

The uranium, thorium, and actinium series refer to uranium-238, thorium-234, and uranium-235 (all naturally occurring radionuclides) and their respective radioactive decay products. The uranium series radionuclides detected at WAG 6 consist of uranium-238, thorium-234, uranium-234, thorium-230, and radium-226. The thorium series radionuclides detected at WAG 6 consist of thorium-232, radium-228, thorium-228, and radium-224. The only actinium series radionuclide detected at WAG 6 was uranium-235. A comparison with background data for all these radionuclides will be performed when site-specific background data are available. This analysis will be presented in the WAG 6 RFI report.

5.2 CHEMICAL CONTAMINATION

Tables 5-7 through 5-12 list organic and inorganic constituents detected at WAG 6. For each constituent, the tables show the range of concentrations detected in each of the environmental media sampled and the respective human health criteria, where available. The ranges shown in Tables 5-7 through 5-10 are based on the available Phase 1, Activity 1 RFI data and ORNL SWSA 6 RCRA Groundwater Quality data (ORNL, 1989 a,b) for groundwater, and Phase 1, Activity 1 RFR data for surface water, subsurface soils, and surface soils, respectively. The ranges shown in Tables 5-11 and 5-12 are based on data from previous investigations. Table 5-11 shows results for trench leachate, groundwater, and surface water samples; Table 5-12 shows results for soils and sediment samples. The human health criteria listed in the tables were developed in Section 7.0. Table 5-13 summarizes TCL compounds detected above human health criteria during Phase 1, Activity 1 of the RFI and compounds for which no criteria were developed.

TABLE 5-7

COMPARISON OF RFI GROUNDWATER DATA FOR
CHEMICALS WITH HEALTH BASED CRITERIA

CAS Number	Compound	Concentration Range (mg/L) (a)	Number of Locations in Which Detected	Number of Samples in Which Detected	Water Health Based Criteria (mg/L) (b)	Reference
Volatiles						
75-01-4	Vinyl Chloride	0.009 - 0.079	2	4	0.002 (c)	SDWA MCL and TENN MCL
75-00-3	Chloroethane	.001 J	1	1	--	
67-64-1	Acetone	.022 J	1	1	3.5	RfDC - IRIS
75-35-4	1,1-Dichloroethene	.0005 J - .005	2	3	0.007	SDWA MCL and TENN MCL
75-34-3	1,1-Dichloroethane	.0006 - .017	4	12	0.00038 (d)	SF - HEA
540-59-0	1,2-Dichloroethene (Total)	.004 J - .47 J	8	21		
67-66-3	Chloroform	.001 J - .074	7	12	0.1 (e)	SDWA MCL
107-06-2	1,2-Dichloroethane	.002 J - .038	3	6	0.005	SDWA MCL and TENN MCL
71-55-6	1,1,1-Trichloroethane	.002 J - .0040 J	3	5	0.2	SDWA MCL and TENN MCL
79-01-6	Trichloroethene	.003 J - 1.3 J	6	14	0.005 (f)	SDWA MCL and TENN MCL
79-00-5	1,1,2-Trichloroethane	.002 J - .003 J	1	2	0.00061	SF - IRIS
71-43-2	Benzene	.002 J - .096	6	18	0.005	SDWA MCL
127-18-4	Tetrachloroethene	.002 J - 6.8	7	11	1 (g)	DW - HA
108-88-3	Toluene	.003 J - 1.9 J	3	7	2 (f)	DW - HA
79-34-5	1,1,2,2-Tetrachloroethane	.005 U - .044	1	1	0.0018	SF - IRIS
100-41-4	Ethyl Benzene	.098 - .7 J	2	5	0.7 (g)	DW - HA
1330-20-7	Xylenes (Total)	.001 J - 3.8 J	4	7	0.1	DW - HA
56-23-5	Carbon Tetrachloride	0.052 - 0.097	1	2	0.005	SDWA MCL and TENN MCL
Semi-Volatiles						
95-48-7	2-Methylphenol	.022	1	1	1.8	RfDC - IRIS
91-20-3	Naphthalene	.001 J - .58	3	8	14	RfDC - HEA
84-66-2	Diethylphthalate	.0015 - .48	6	6	28 (f)	RfDC - IRIS
84-74-2	Di-n-butylphthalate	.0005 J - .019	6	8	3.5 (f)	RfDC - IRIS
117-81-7	bis(2-Ethylhexyl)phthalate	.0007 J - .005 J	3	4	0.0025 (f)	SF - IRIS
Pesticides						
11097-69-1	Aroclor 1254	.0006 J - .001 J	2	2	0.001 (g,h)	DW - HA
Analytes						
7429-90-5	Aluminum	.064 - 110	32	94	-- (f)	RfDC - IRIS
7440-36-0	Antimony	.03 U - .0915	1	1	0.014	SDWA MCL and TENN MCL
7440-38-2	Arsenic	.002 UJ - .0665 J	6	12	0.05	SDWA MCL and TENN MCL
7440-39-3	Barium	.131 J - 4.83	13	34	1 (f)	RfDC - IRIS
7440-41-7	Beryllium	.000033 - .871	32	75	0.18	SDWA MCL and TENN MCL
7440-43-9	Cadmium	.002 - .0945	8	12	0.01	SDWA MCL and TENN MCL
7440-70-2	Calcium	.4 - 206	34	110	-- (i)	SDWA MCL and TENN MCL
7440-47-3	Chromium VI	.01 U - .21	11	16	0.05	SDWA MCL and TENN MCL
7440-48-4	Cobalt	.0068 - .104	6	10	--	TENN WMCL
7440-50-8	Copper	.01 J - .117 U	14	19	1	

TABLE 5-7 (Continued)

CAS Number	Compound	Concentration Range (mg/L) (a)	Number of Locations in Which Detected	Number of Samples in Which Detected	Water Health Based Criteria (mg/L) (b)	Reference
7439-89-6	Iron	.07 - 110	34	102	--	SDWA MCL and TENN W&HCL
7439-92-1	Lead	.006 - .0721	7	12	0.05	
7439-95-4	Magnesium	.51 - 48	35	112	--	
7439-96-5	Manganese	.01 - 15.5	32	102	7 (f)	RfDc - HEA
7439-97-6	Mercury	.0001 - .0024 J	10	12	0.002	SDWA MCL and TENN MCL
7440-02-0	Nickel	.0066 - .219	23	40	0.1	TENN WMCL
7440-09-7	Potassium	1 U - 42.7	11	26	--	
7782-49-2	Selenium	.005	1	1	0.01	SDWA MCL and TENN MCL
7440-22-4	Silver	.005 UF - .0726	6	6	0.05	SDWA MCL and TENN MCL
7440-23-5	Sodium	1.1 - 86	35	111	--	
7440-62-2	Vanadium	.0048 U - .161	30	86	0.035	RfDc - HEA
7440-66-6	Zinc	.0074 - .034	20	23	5	TENN WMCL

(a) Concentration ranges are for unfiltered samples. Data qualifiers are: J = estimated value; U = not detected, value given is quantitation limit.

(b) The development of health based criteria is discussed in Section 7.0.

(c) "n" = No health based criteria are available.

(d) cis 1,2-Dichloroethene = .007 mg/L and Trans 1,2-Dichloroethene = .1 mg/L.

(e) Value is that for the sum of bromodichloromethane, dibromochloromethane, bromoform, and chloroform.

(f) Slope factor or reference dose was used instead of water quality criteria value.

(g) Health advisory was used instead of water quality criteria value.

(h) Value is for PCBs.

(i) Value is for total Chromium.

TABLE 5-8

COMPARISON OF RFI SURFACE WATER DATA FOR
CHEMICALS WITH HEALTH BASED CRITERIA

CAS Number	Compound	Concentration Range (mg/L) (a)	Number of Locations in Which Detected	Number of Samples in Which Detected	Water Health Based Criteria (mg/L) (b)	Reference
Volatiles						
67-64-1	Acetone	.004 J - .010 U	2	2	3.5	RfDC - IRIS
75-15-0	Carbon Disulfide	.003 - .010 U	1	1	3.5	RfDC - IRIS
75-35-4	1,1-Dichloroethene	.002 J - .005 U	2	2	0.007	SDWA MCL and TENN MCL
75-34-3	1,1-Dichloroethane	.003 J - .006	1	3	0.00038 (c)	SF - HEA
540-59-0	1,2-Dichloroethene (Total)	.005 UF - .180	6	12		
107-06-2	1,2-Dichloroethane	.002 J	1	1	0.005	SDWA MCL and TENN MCL
78-93-3	2-Butanone	.010 J - .012	1	2	1.8 (d)	RfDC - IRIS
108-05-4	Vinyl Acetate	.001 J - .010 U	1	1	--	
79-01-6	Trichloroethene	.002 J - 2.200 J	8	14	0.005	SDWA MCL and TENN MCL
71-43-2	Benzene	.002 J - .005 U	2	2	0.005	SDWA MCL and TENN MCL
108-10-1	4-Methyl-2-pentanone	.001 J - .010 U	1	1	1.8 (e)	RfDC - IRIS
127-18-4	Tetrachloroethene	.001 J - .005 U	2	2	1	DW - HA
108-88-3	toluene	.001 J - .005 U	3	3	2 (e)	DW - HA
79-34-5	1,1,2,2-Tetrachloroethene	.001 J - .005 U	1	1	0.0018 (f)	SF - IRIS
108-90-7	Chlorobenzene	.002 J - .005 U	2	2	0.1 (e)	DW - HA
Semi-Volatiles						
91-20-3	Naphthalene	.002 J - .010 U	1	1	14 (f)	RfDC - HEA
87-74-2	Di-n-butylphthalate	.003 J - .010 U	2	2	3.5 (f)	RfDC - IRIS
117-81-7	bis(2-Ethylhexyl)phthalate	.002 J - .010 U	2	2	0.0025 (f)	SF - IRIS
Analytes						
7429-90-5	Aluminum	.040 U - 13.200	15	30	-- (f)	RfDC - IRIS
7440-36-0	Antimony	.030 U - .030	1	1	0.014	SDWA MCL and TENN MCL
7440-38-2	Arsenic	.002 J - .0159 J	6	6	0.05	SDWA MCL and TENN MCL
7440-39-3	Barium	.031 J - 2.600 J	14	27	1 (f)	RfDC - IRIS
7440-41-7	Beryllium	.001 J - .0036 J	7	8	0.18	SDWA MCL and TENN U&MCL
7440-43-9	Cadmium	.0028 J - .006	4	4	0.01	SDWA MCL and TENN U&MCL
7440-70-2	Calcium	27.900 - 94.900	13	27	-- (e)	SDWA MCL and TENN U&MCL
7440-47-3	Chromium VI	.010 U - .032	12	21	0.05	TENN WMCL
7440-48-4	Cobalt	.0109 J	1	1	--	
7440-50-8	Copper	.010 U - .081	4	4	1	SDWA MCL and TENN U&MCL
7439-89-6	Iron	.160 - 17.000 J	8	25	--	
7439-92-1	Lead	.002 J - .014	4	5	0.05	RfDC - HEA
7439-95-4	Magnesium	2.600 J - 13.200	14	26	-- (f)	SDEA MCL and TENN MCL
7439-96-5	Manganese	.002 - 1.480	15	30	0.002	TENN WMCL
7439-97-6	Mercury	.0002 U - .0005	3	6	0.1	
7440-02-0	Nickel	.0239	1	1	--	SDWA MCL and TENN U&MCL
7440-09-7	Potassium	1.000 U - 8.760	12	20	0.01	
7782-49-2	Selenium	.003 U - .003 J	3	3	0.05	
7440-22-4	Silver	.005 U - .047	4	4		

TABLE 5-8 (Continued)

CAS Number	Compound	Concentration Range (mg/L) (a)	Number of Locations in Which Detected	Number of Samples in Which Detected	Water Health Based Criteria (b) (mg/L)	Reference
7440-23-5	Sodium	1.360 - 13.200	14	25	--	
7440-62-2	Vanadium	.010 U - .019 J	8	10	0.035	RfDc - HEA
7440-66-6	Zinc	.008 U - 1.260 J	4	4	5	TENN WMCL

(a) Concentration ranges are for unfiltered samples. Data qualifiers are: J = estimated value; U = not detected, value given is quantitation limit.

(b) The development of health based criteria is discussed in Section 7.0.

(c) Cis 1,2-Dichloroethene = .007 mg/L and Trans 1,2-Dichloroethene = .1 mg/L.

(d) "--" = No health based criteria are available.

(e) More recently published health advisory was used instead of water quality criteria value.

(f) More recently published scope factor or reference dose was used instead of water quality criteria value.

(g) Value is for total Chromium.

TABLE 5-9

COMPARISON OF RFI SUBSURFACE SOIL CHEMICALS
WITH HEALTH BASED CRITERIA

CAS Number	Compound	Concentration Range (a) (µg/kg or mg/kg)	Number of Locations in Which Detected (37 Total)	Number of Samples in Which Detected (58 Total)	Soil Health Based Criteria (µg/kg or mg/kg) (b)	Reference
Volatiles						
75-09-2	Methylene Chloride	1 J - 13 J	8	10	µg/kg	SF - IRIS
67-64-1	Acetone	3 J - 1800 J	28	40	93,000,000	RfDc - IRIS
75-15-0	Carbon Disulfide	8	1	1	8,000,000	RfDc - IRIS
540-59-0	1,2-Dichloroethene (Total)	9 - 39	3	3	8,000,000 (c)	
67-66-3	Chloroform	2 J - 34	2	3	119,000,000	SF - IRIS
78-93-3	2-Butanone	1 J - 6 J	5	7	4,000,000	RfDc - IRIS
79-01-6	Trichloroethene	1 J - 150	5	6	--	
591-78-6	2-Hexanone	1 J	1	1	--	
127-18-4	Tetrachloroethene	9 J - 420 J	2	2	14,000	SF - HEA
108-88-3	Toluene	2 J - 190	9	10	24,000,000	RfDc - IRIS
108-90-7	Chlorobenzene	1 J	1	1	1,600,000	RfDc - IRIS
100-41-4	Ethyl Benzene	1 J - 6 J	8	11	8,000,000	RfDc - IRIS
1330-20-7	Xylene (Total)	1 J - 7	12	16	160,000,000	RfDc - IRIS
Semi-Volatiles						
		(µg/kg)			(µg/kg)	
108-95-2	Phenol	43 J - 93 J	1	1	48,000,000	RfDc - HEA
100-51-6	Benzyl alcohol	260 J - 350 J	3	5	--	
65-85-0	Benzoic acid	67 J	1	1	320,000,000	RfDc - IRIS
91-20-3	Naphthalene	130 J	1	1	32,000,000	RfDc - HEA
84-66-2	Diethylphthalate	45 J - 65 J	2	2	64,000,000	RfDc - IRIS
86-30-6	N-nitrosodiphenylamine	61 J	1	1	140,000	SF - IRIS
84-74-2	Di-n-butylphthalate	170 J - 1900 J	3	3	8,000,000	RfDc - HEA
56-55-3	Benzo(a)anthracene	51 J	1	1	--	
218-01-9	Chrysene	79 J - 140 J	2	2	--	
117-81-7	bis(2-Ethylhexyl)phthalate	86 J - 950 J	6	8	50,000	SF - IRIS
117-84-0	Di-n-octylphthalate	58 - 320 J	3	3	--	
205-99-2	Benzo(b)fluoranthene	70 J	1	1	--	
207-08-9	Benzo(k)fluoranthene	40 J	1	1	--	
50-32-8	Benzo(a)pyrene	37 J - 140 J	2	2	--	
		(µg/kg)			(µg/kg)	
Analytes						
7429-90-5	Aluminum	11000 - 31700			--	
7440-36-0	Antimony	<.01 J - 1.2 J			--	RfDc - IRIS
7440-38-2	Arsenic	<1 J - 195			32	RfDc - HEA
7440-39-3	Barium	68.6 - 420			80	RfDc - IRIS
7440-41-7	Beryllium	<.9 J - 2			4000	RfDc - IRIS
7440-43-9	Cadmium	<.5 J - 6.1			400	
7440-70-2	Calcium	290 J - 54700			--	
7440-47-3	Chromium VI	24 J - 52.3			--	RfDc - IRIS
7440-48-4	Cobalt	11 J - 120 J			400 (d)	
					--	

TABLE 5-9 (Continued)

CAS Number	Compound	Concentration Range ($\mu\text{g/kg}$ or mg/kg)	Number of Locations in Which Detected	Number of Samples in Which Detected	Soil Health Based Criteria ($\mu\text{g/kg}$ or mg/kg) (a)	Reference
7440-50-8	Copper	6 J - 86.7 J			--	
57-12-5	Cyanide	<.06 - 3.2			1,600	RfDc - IRIS
7439-89-6	Iron	21300 - 44500			--	
7439-92-1	Lead	3.2 - 243 J			--	
7439-95-4	Magnesium	65 - 45700			--	
7439-96-5	Manganese	282 - 7230 J			16,000	RfDc - HEA
7439-97-6	Mercury	<0.02 - 0.7 J			24	RfDc - HEA
7440-02-0	Nickel	24 - 86.6 J			1,600	RfDc - IRIS
7440-09-7	Potassium	399 - 4570 J			--	
7782-49-2	Selenium	<0.3 - 0.9 J			240	RfDc - HEA
7440-22-4	Silver	<0.1 - 0.6 J			240	RfDc - IRIS
7440-23-5	Sodium	<40 J - 194 J			--	
7440-28-0	Thallium	<0.2 J - 1			5.6	RfDc - HEA
7440-62-2	Vanadium	8.5 J - 34 J			80	RfDc - PHRED
7440-66-6	Zinc	37.7 - 143 J			16,000	

(a) Data qualifiers are: J = estimated value; U = not detected, value given is quantitation limit.

(b) The development of health based criteria is discussed in Section 7.0.

(c) "--" = No health based criteria were available.

(d) Number is for total Chromium.

TABLE 5-10
COMPARISON OF RFI SURFACE SOIL DATA FOR CHEMICALS
WITH ENVIRONMENTAL CRITERIA

CAS Number	Compound	Concentration Range (a), ug/Kg	Number of Locations	Health Criteria (b), ug/Kg	Reference
75-09-2	Methylene Chloride	--(c) - 3J	Not Listed	93,000,000	SF-IRIS
79-01-6	Trichloroethene	-- - 2J	"		
108-88-3	Toluene	-- - 16	"	24,000,000	RfDc-IRIS

(a) Data qualifier: J = estimated value.

(b) The development of health criteria is discussed in Section 7.0.

(c) "--", not detected.

TABLE 5-11

COMPARISON OF TRENCH LEACHATE AND GROUNDWATER CHEMICAL DATA FROM
PREVIOUS INVESTIGATIONS WITH HEALTH BASED CRITERIA

CAS Number	Compound	Concentration Range (mg/L)	Number of Locations in which Detected (a)	Health Based Criter- ia (b) (mg/L)	Reference
<u>Trench Leachate (Solomon, et al., 1988)</u>					
<u>Volatiles</u>					
75-00-3	Chloroethane	<.01-.049	1	-- (c)	
75-34-3	1,1 Dichloroethane	<.005-.626	1	.00038	SF-HEA
79-01-6	Trichloroethane	.002-.008	2	.005	SDWA MCL & TN MCL
71-43-2	Benzene	.0044-.929	3	.005	SDWA MCL
542-75-6	Cis 1,3 Dichloro- propene	<.005-.058	1	--	
127-18-4	Tetrachloroethene	<.0041-1.182	1	1	DW-HA
108-88-3	Toluene	.014-1.94	4	2	DW-HA
100-41-4	Ethyl Benzene	<.005-.072	2	.7	DW-HA
100-42-5	Styrene	<.005-.007	1	.005	SDWA MCL
1330-20-7	Xylenes (total)	.011-3.7	2	.1	DW-HA
<u>Semi-Volatiles</u>					
108-95-2	Phenol	<.01-.013	2	3.5	DW-HA
106-44-5	4-Methylphenol	.034-.091	2	--	
91-20-3	Naphthalene	.051-1.704	3	14	RfDc-HEA
105-67-9	2, 4 Dimethyl phenol	<.01-.032	1	.4	DW-HA
95-48-7	o-cresol	<.01-.026	1	--	
106-44-5	p-cresol	<.01-.141	1	--	
<u>Groundwater, Solomon, et al., 1988</u>					
<u>Volatiles</u>					
75-09-2	Methylene Chloride	.04-.256	2	.00019	DW-HA
75-34-3	1,1 Dichloroethane	<.005-.01	1	.00038	SF-HEA
67-66-3	Chloroform	.085-.087	2	.1	SDWA MCL
107-06-2	1,2 Dichloroethane	<.0028-.023	1	.005	SDWA MCL
79-34-5	1,1,2,2 Tetrachloroethene	<.005-.055	1	.0018	SF-IRIS
79-01-6	Trichloroethene	.002-2.323	2	.005	SDWA MCL & TN MCL
71-43-2	Benzene	.013-.07	2	.005	SDWA MCL
127-18-4	Tetrachloroethene	<.0041-1.97	1	1	DW-HA
108-88-3	Toluene	.01-1.94	2	2	DW-HA
100-41-4	Ethyl Benzene	<.005-.72	1	.7	DW-HA
1330-20-7	Xylenes (total)	<.005-.006	1	.1	DW-HA

TABLE 5-11 (Continued)

CAS Number	Compound	Concentration Range (mg/L)	Number of Locations in which Detected (a)	Health Based Criteria (b) (mg/L)	Reference
<u>Semi-Volatiles</u>					
108-95-2	Phenol	<.01-.013	1	3.5	DW-HA
105-67-9	2,4 Dimethylphenol	<.01-.032	1	.4	DW-HA
91-20-3	Naphthalene	<.01-1.7	1	14	RfDc-HEA
117-81-7	Bis (2-ethylhexyl) phthalate	<.01-.013	1	.0025	SF-IRIS
95-48-7	o-cresol	<.01-.026	1	--	
106-44-5	p-cresol	<.01-.141	1	--	

(a) Total number of locations is eight.

(b) The development of health criteria is discussed in Section 7.0.

(c) Total number of locations is five.

TABLE 5-12
COMPARISON OF SOIL CHEMICAL DATA FROM PREVIOUS
INVESTIGATIONS WITH HEALTH CRITERIA

CAS Number	Compound	Concentration Range (a) ($\mu\text{g/kg}$)	Number of Locations Detected	Health Based Criteria ($\mu\text{g/kg}$)	Reference
75-09-2	Methylene Chloride	17-107	10	93,000	SF-IRIS
84-66-2	Diethylphthalate	82J-172J	8	64,000,000	RfDc-IRIS
84-74-2	Di-n-butylphthalate	28J-39J	6	8,000,000	RfDc-HEA

(a) Data qualifier: J = estimated value.

The discussion of chemicals detected at WAG 6 is presented in three parts: Section 5.2.1 describes information regarding potential source areas of chemical wastes, Section 5.2.2 describes the distribution of organic compounds, and Section 5.2.3 briefly discusses inorganic constituents.

Figure 5-9 indicates known chemical disposal areas. Figures 5-10 through 5-22 and figures 5-24 present the maximum concentrations detected of several organic chemicals of interest. To aid the reader in interpretation the sample location symbols are sized according to the relative concentrations of the analytes. Arrows are also shown which indicate the general direction of potential contaminant migration. These arrows are meant to show where there is some evidence of migration or the potential for migration and the general direction of migration expected. They do not show the precise direction or magnitude of contaminant migration nor do they necessarily indicate that a complete pathway (i.e. trench leachate to groundwater to surface water) has been observed. The arrows are located assuming gradient dominated flow. Source areas and migration pathways will be refined during the remainder of the RFI process.

Although the maximum concentrations of many of the chemical contaminants seem to be lowest in trench leachate, intermediate in groundwater, and highest in surface water (a contradiction of logic) this may be an artifact of the data presentation method. Since only the maximum concentration detected of an analyte is reported, and the data come from several sampling events, pathway relationships may be implied that do not actually exist. Careful examination of data from each sampling event along with information regarding surface drainage and hydrogeology will be performed to assess pathway relationships and the results presented in the RFI report.

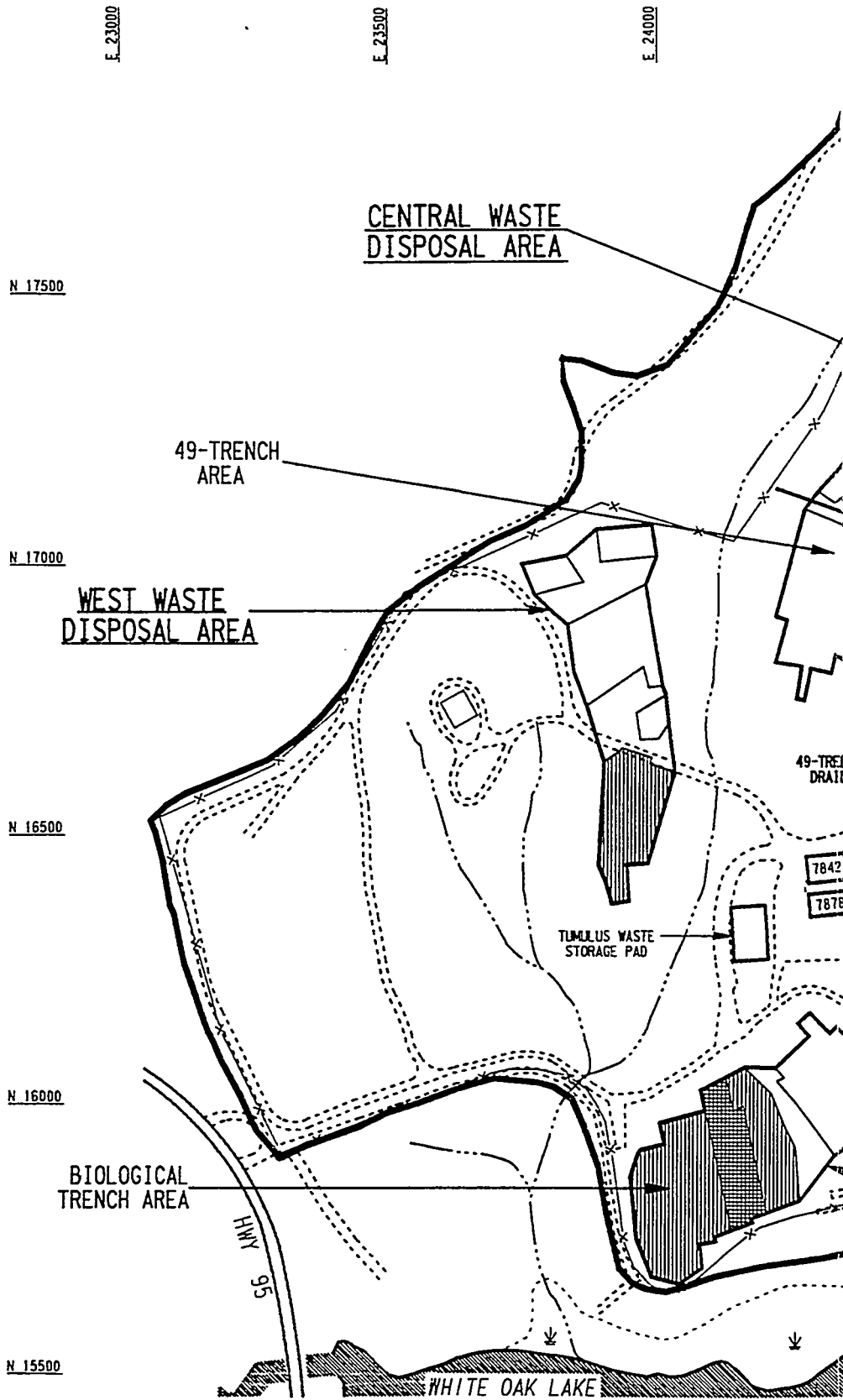
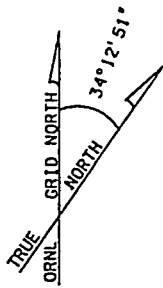
5.2.1 Source Areas

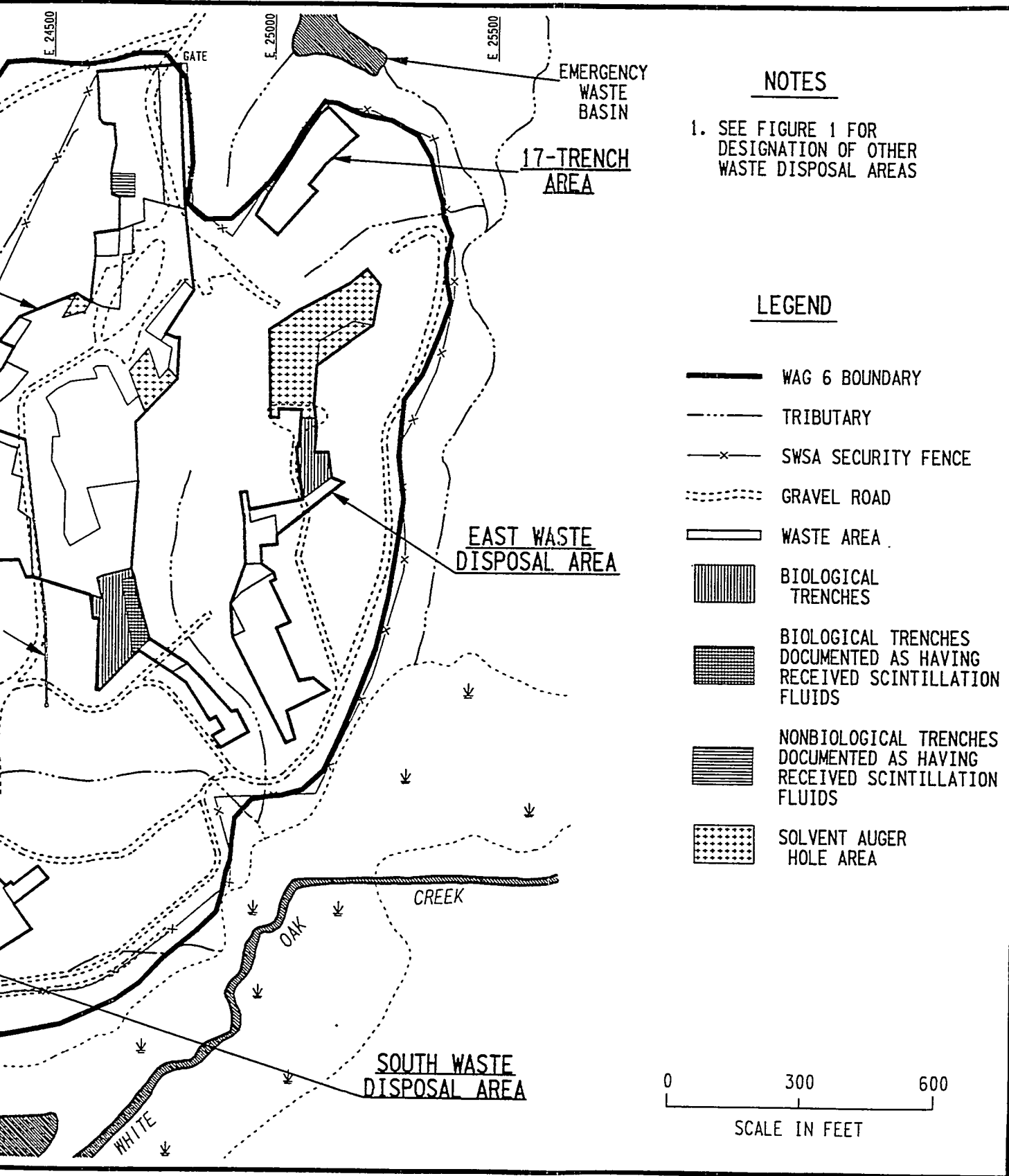
WAG 6 is generally designated as a low-level radioactive waste disposal area; however, some chemicals were disposed with the radioactive wastes from the time the site was opened in 1969 to May 1986. Chemical wastes are known to have been disposed both in auger holes and trenches. One class of auger holes, designated as "solvent auger holes," contains oils, cleaning solutions, alcohols, paint thinners, kerosene, jet fuel, acids, sodium, and miscellaneous solvents and other chemicals (ORNL, 1986). Container sizes ranged from small bottles and cans up to 55-gallon drums. The exact nature and volume of wastes that went into individual auger holes is unknown.

Based on waste disposal records, the class of trenches designated as biological trenches received a significant volume of waste scintillation fluids. Records indicate that from 1972 through May 1983, approximately 48,000 liters of scintillation fluids were disposed (this is equivalent to approximately 230 55-gal drums). Thirty-five biological trenches have been identified as containing scintillation fluids (ORNL, 1986).

Because chemical disposal activities were not thoroughly documented, it is not precisely known what chemicals were disposed of, or in what trenches and auger holes they were placed. Areas containing solvent auger holes and the 35 biological trenches mentioned above are indicated on Figure 5-9.

Trench leachate sampling and analysis for chemical contamination has been performed by Solomon et al. (1988). Leachate was collected from seven trenches and analyzed for the EPA TCL. Organic chemicals, including 10 VOCs and 6 SVOCs, were found in all samples. Organic chemicals which were identified are listed in Table 5-11. Trench leachate data should be interpreted in light of the observations made by Solomon et al. (1988) regarding





large and erratic variations in trench leachate concentrations with changing hydraulic conditions. This variability and the extremely large number of trenches present lead Solomon et al (1988) to conclude that leachate sampling was not a viable method to identify source terms. This is discussed in Section 5.1.1.

5.2.2 Organic Chemical Contamination

Approximately 25 TCL VOCs and 17 TCL SVOCs were detected during the Phase 1, Activity 1 RFI. Of the 22 TCL VOCs detected for which human health criteria are available, 14 were present at levels exceeding those criteria. Of the 8 TCL SVOCs for which human health criteria are available, only one was present at levels exceeding those criteria. The TCL compounds that exceed human health criteria and those for which no criteria are presented in Section 7.0 are listed in Table 5-13.

In addition to the TCL compounds detected, approximately 65 tentatively identified compounds (TICs) were named; of these, approximately 15 were VOCs and 50 were SVOCs. (TICs are compounds for which analysis was not requested but for which presence was indicated in laboratory analytical results.) TICs identified in the various media sampled are listed in the respective technical memoranda included in Appendix A. Human health criteria have not been identified for TICs.

5.2.2.1 Volatile Organic Compounds. VOCs detected at WAG 6 can generally be classified as: halogenated alkenes and alkanes (HAAs); benzene, toluene, and xylene (BTX) compounds; or ketones. A small number of the compounds detected fall outside these groupings and are designated for the purposes of this discussion as "other VOC compounds." The areal distribution of each of the above groups of compounds is discussed separately below.

TCL ORGANIC COMPOUNDS DETECTED AT WAG 6

SOIL			
Organic Compound	Range ^(a) (µg/kg)	Health Criteria (µg/L)	Reference

COMPOUNDS EXCEEDING HEALTH CRITERIA^(b)

None

COMPOUNDS DETECTED AT LESS THAN HEALTH CRITERIA

Volatiles

Methylene chloride	.001J - .013J	93,000	SF-IRIS
Acetone	.003J - 1.8J	8,000	RfDc-IRIS
Carbon disulfide	.008	8,000	RfDc-IRIS
Chloroform	.002J - .034	110,000	SF-IRIS
2-Butanone	.001J - .006J	4,000	RfDc-IRIS
Tetrachloroethene	.009J - .420J	14	SF-HEA
Toluene	.002J - .190	24,000	RfDc-IRIS
Chlorobenzene	.001J	1,600	RfDc-IRIS
Ethyl benzene	.001J - .006J	8,000	RfDc-IRIS
Xylenes (total)	.001J - .007	160,000	RfDc-IRIS

Semi-Volatiles

Phenol	.043J - .093J	48,000	RfDc-IRIS
Benzoic acid	.067J	320,000	RfDc-IRIS
Naphthalene	.130J	32,000	RfDc-HEA
Diethylphthalate	.045J - .065J	64,000	RfDc-IRIS
N-nitrosodiphenylamine	.061J	140	SF-IRIS
Di-n-butylphthalate	.170J - 1.900J	8,000	RfDc-HEA
Bis(2-ethylhexyl) phthalate	.086J - .950J	50	SF-IRIS

COMPOUNDS FOR WHICH NO HEALTH CRITERIA HAVE BEEN DEVELOPED

Volatiles

1,2 Dichloroethene
2-Hexanone

Semi-Volatiles

Benzyl alcohol
Benzo(a) anthracene
Chrysene
Di-n-octyl phthalate
Benzo(b) fluoranthene
Benzo(a) pyrene

TABLE 5-13 (Continued)

SURFACE WATER			
Organic Compound	Range ($\mu\text{g/L}$)	Health Criteria ($\mu\text{g/L}$)	Reference
COMPOUNDS EXCEEDING HEALTH CRITERIA			
<u>Volatiles</u>			
1,1 Dichloroethene	3J-6	.38	SF-IRIS
1,2 Dichloroethene	3J-180	(c)	
Trichloroethene	2J-2,200J	5	SDWA MCL & TN MCL
Benzene	2J-5U	5	SDWA MCL & TN MCL
<u>Semi-Volatiles</u>			
Bis(2-ethylhexyl) phthalate	2J-10U	2.5	SF-IRIS
COMPOUNDS DETECTED AT LESS THAN HEALTH CRITERIA			
<u>Volatiles</u>			
Acetone	4J-10U	3,500	RfDc-IRIS
Carbon disulfide	3-10U	3,500	RfDc-IRIS
1,1 Dichloroethene	2J-5U	7	RfDc-IRIS
1,2 Dichloroethane	2J	5	SDWA MCL & TN MCL
2-Butanone	10J-12	1,800	RfDc-IRIS
4-Methyl-2 Pentanone	1J-10U	1,800	RfDc-IRIS
Tetrachloroethene	1J-5U	1,000	DW-HEA
Toluene	1J-5U	2,000	DW-HEA
1,1,2,2 Tetrachloro- ethene	1-5U	1.8	SF-IRIS
Chlorobenzene	2J-5U	100	DW-HEA
<u>Semi-Volatiles</u>			
Naphthalene	2J-10U	14,000	RfDc-HEA
Di-n-butylphthalate	3J-10U	3,500	RfDc-IRIS

COMPOUNDS FOR WHICH NO HEALTH CRITERIA HAVE BEEN DEVELOPED
Vinyl Acetate

TABLE 5-13 (Continued)

GROUNDWATER			
Organic Compound	Range (µg/L)	Health Criteria (µg/L)	Reference
COMPOUNDS EXCEEDING HEALTH CRITERIA			
Volatiles			
Vinyl chloride	9-79	2	SDWA MCL & TN MCL
1,1 Dichloroethene	6-17	3.8	SF-HEA
1,2 Dichloroethene	4J-470J	(c)	
1,2 Dichloroethane	2J-38	5	SDWA MCL & TN MCL
Trichloroethene	3J-1,300J	5	SDWA MCL & TN MCL
1,1,2 Trichloroethane	2J-3J	.6	SF-IRIS
Benzene	2J-96	5	SDWA MCL & TN MCL
Tetrachloroethene	2J-6,800	1,000	DW-HEA
Toluene	3J-1,900	2,000	DW-HEA
1,1,2,2 Tetrachloroethene	5U-44	1.8	SF-IRIS
Ethyl benzene	098-700J	700	DW-HEA
Xylenes (Total)	1J-3,800J	100	DW-HEA
Carbon tetrachloride	.052-.097	.005	SDWA MCL & TN MCL
Semi-Volatiles			
Bis(2-ethylhexyl) phthalate	.7J-5J	2.5	SF-IRIS
Pesticides/PCBs			
Aroclor 1254	.6J-1J	1	DW-HEA
COMPOUNDS DETECTED AT LESS THAN HEALTH CRITERIA			
Volatiles			
Acetone	22J	3,500	RfDc-IRIS
1,1 Dichloroethene	.5J-5	.7	SDWA MCL & TN MCL
Chloroform	1J-74	100	SWDA MCL
1,1,1 Trichloroethane	2J-4J	200	SDWA MCL & TN MCL
Semi-Volatiles			
2-Methylphenol	22	1,800	RfDc-IRIS
Naphthalene	1J-580	14,000	RfDc-HEA
Diethylphthalate	1.5-480	28,000	RfDc-IRIS
Di-n-butylphthalate	.5J-19	3,500	RfDc-IRIS
COMPOUNDS FOR WHICH NO CRITERIA HAVE BEEN DEVELOPED			
Chloroethane			

(a) Data qualifiers: J = estimated value; U = not detected, value given is quantitation limit.

(b) Human Health criteria are identified in Seciton 7.0.

(c) Cis 1,2-Dichloroethene = 0.007 mg/L and Trans 1,2-Dichloroethene = 0.1mg/L.

Halogenated Alkenes and Alkanes

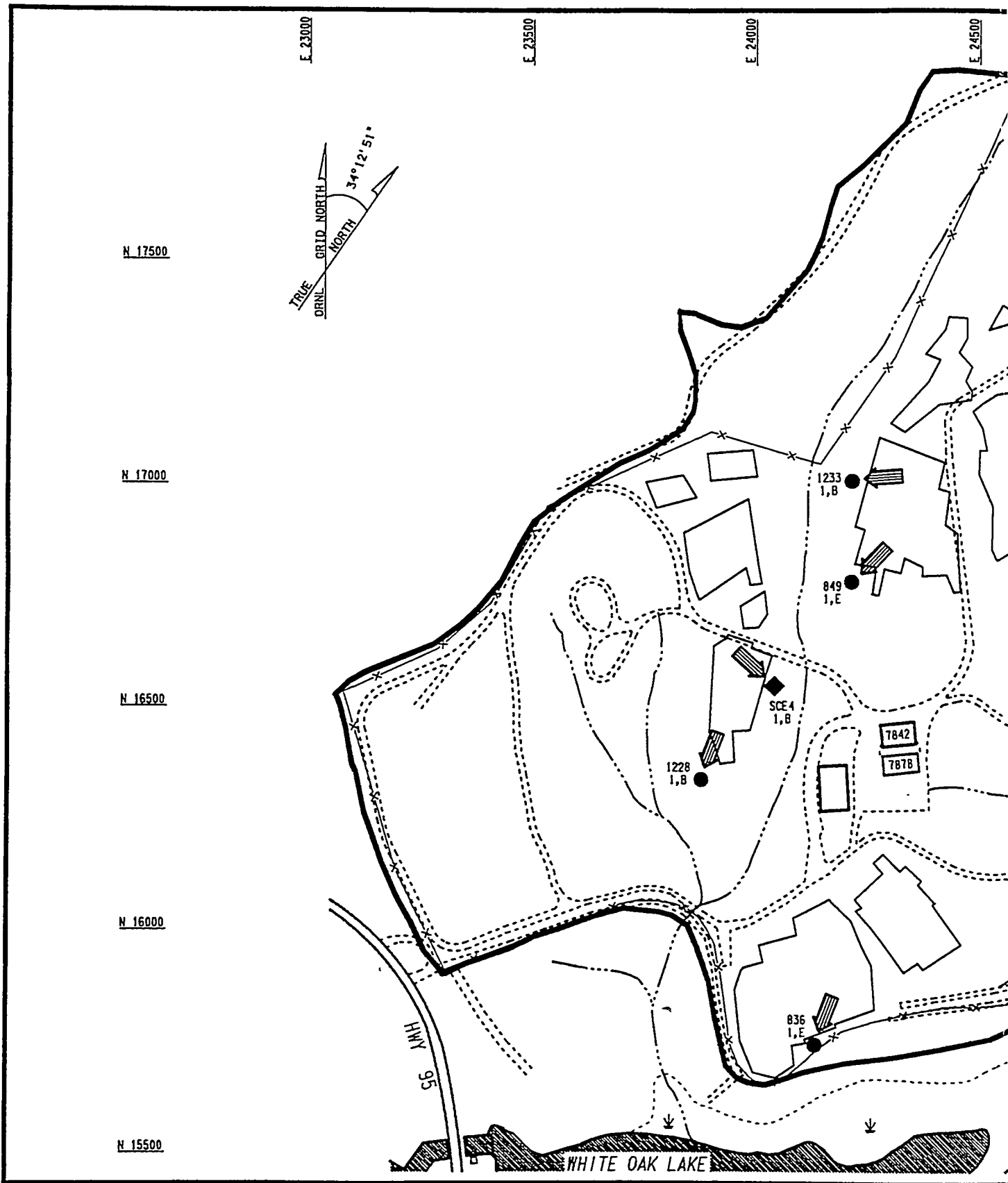
HAAs account for most of the VOCs detected at WAG 6. Ten HAAs were present at levels exceeding the criteria for water. None were present at levels exceeding human health criteria for soils. The distributions of compounds exceeding water criteria (except carbon tetrachloride) are shown in the following series of figures:

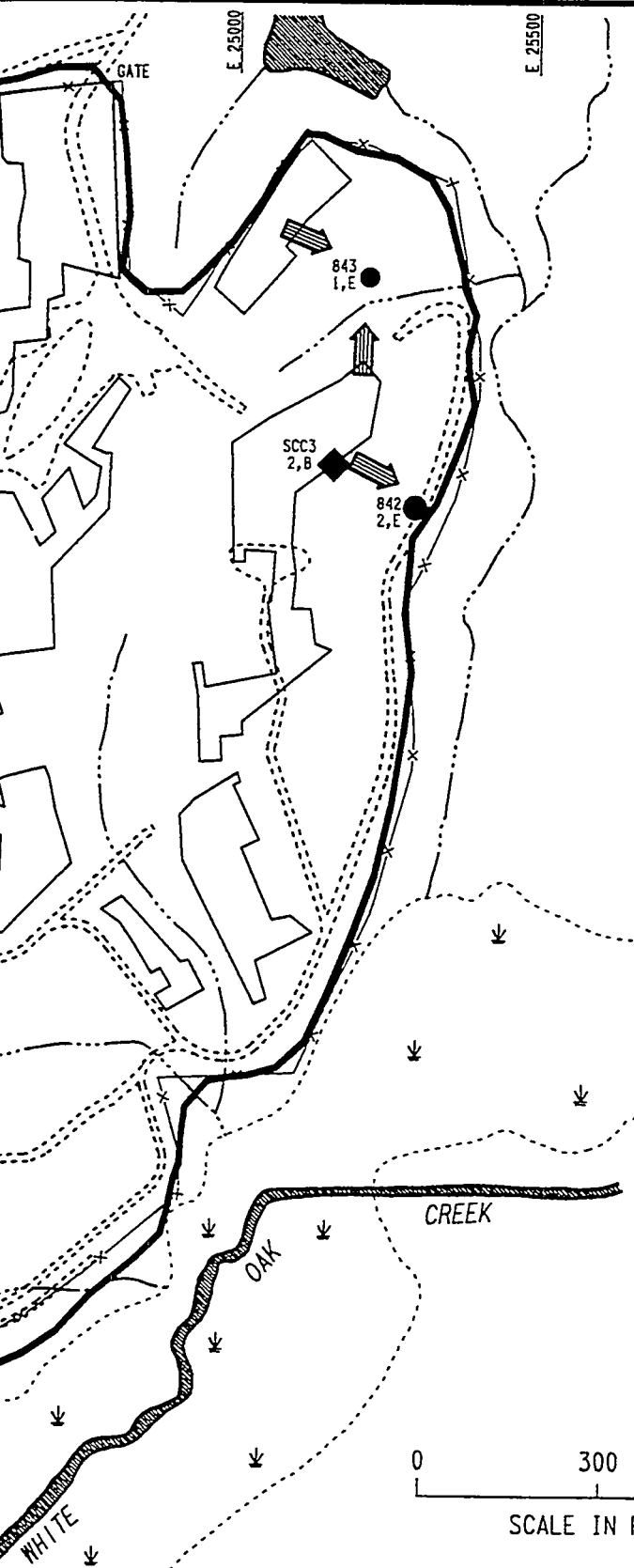
- Figure 5-10 [chloroform (trichloromethane)]
- Figure 5-11 [vinyl chloride (chloroethene)]
- Figure 5-12 (1,2-dichloroethene)
- Figure 5-13 (trichloroethene)
- Figure 5-14 (tetrachloroethene)
- Figure 5-15 (1,1-dichloroethane)
- Figure 5-16 (1,2-dichloroethane)
- Figure 5-17 (1,1,2-trichloroethane)
- Figure 5-18 (1,1,2,2-tetrachloroethane)

The following paragraphs briefly discuss the distributions of the HAAs detected at levels exceeding human health criteria.

Chloroform. Chloroform was detected at six groundwater sampling locations and two soil sampling locations (Figure 5-10). In groundwater, the maximum levels detected approach human health criteria at only one location: 79 ppb at Well 842. For comparison, the SDWA MCL for chloroform is 100 ppb. In soils, the maximum levels detected at each location are at least two orders of magnitude less than the human health criteria developed in Section 7.0 (110,000,000 ppb).

The data indicate that chloroform is migrating from the solvent auger hole group at the north end of the east disposal area downslope to the WAG boundary. This is evidenced by a level of 34 ppb detected in soil boring SCC3 on the eastern perimeter of the solvent auger hole area and by the level of 79 ppb detected





NOTES

1. ALL SURFACE WATER, GROUNDWATER, AND LEACHATE CONCENTRATIONS IN UG/L.
2. ALL SOIL CONCENTRATIONS IN UG/KG.
3. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
4. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
5. THE RANGES OF CONCENTRATIONS INDICATED ARE AS FOLLOWS:

1 =	1 - 9.9
2 =	10 - 99
3 =	100 - 999
4 =	1000 - 9,999
5 =	10,000 - 99,999

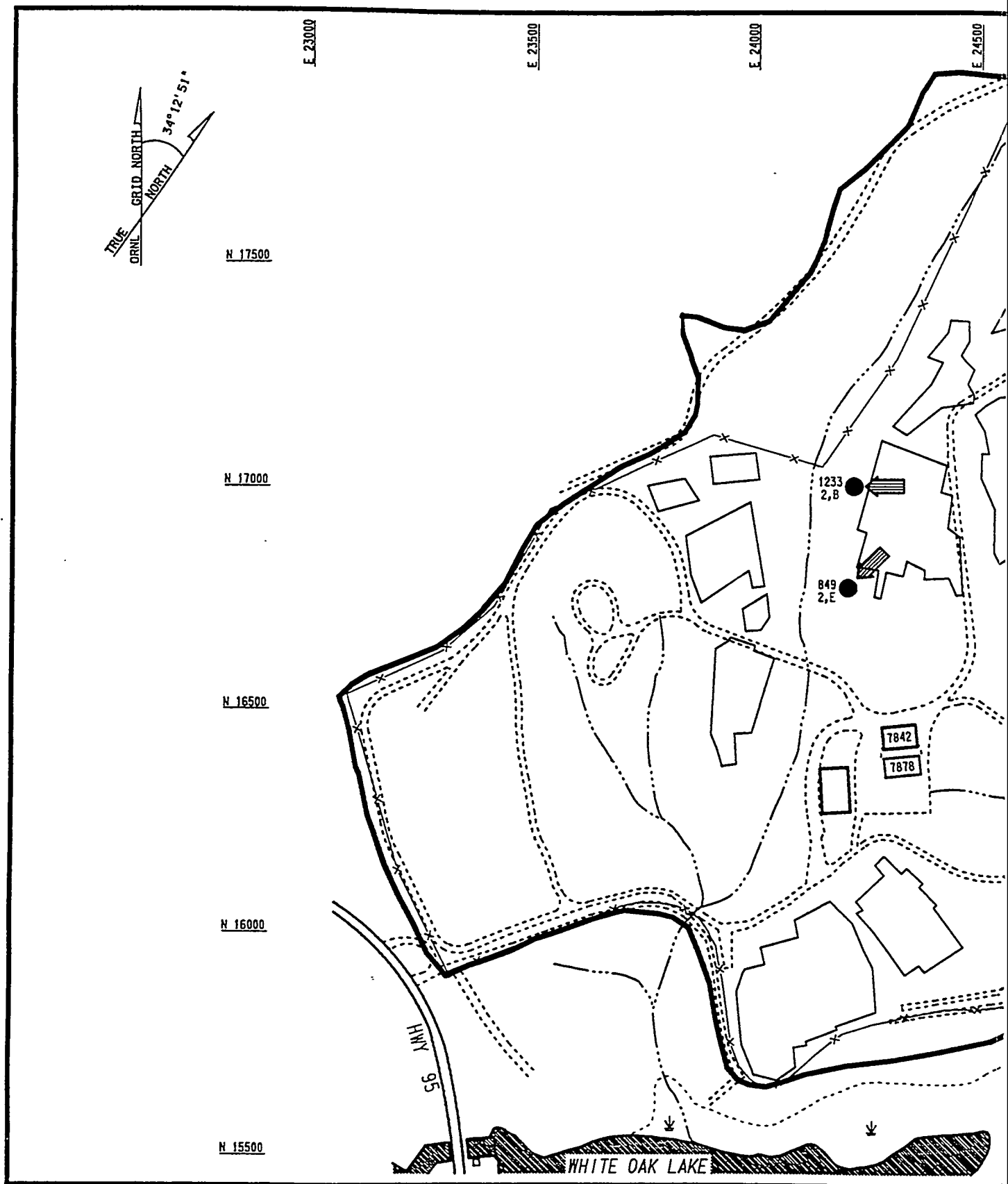
6. THE SOURCES OF DATA ARE AS FOLLOWS:

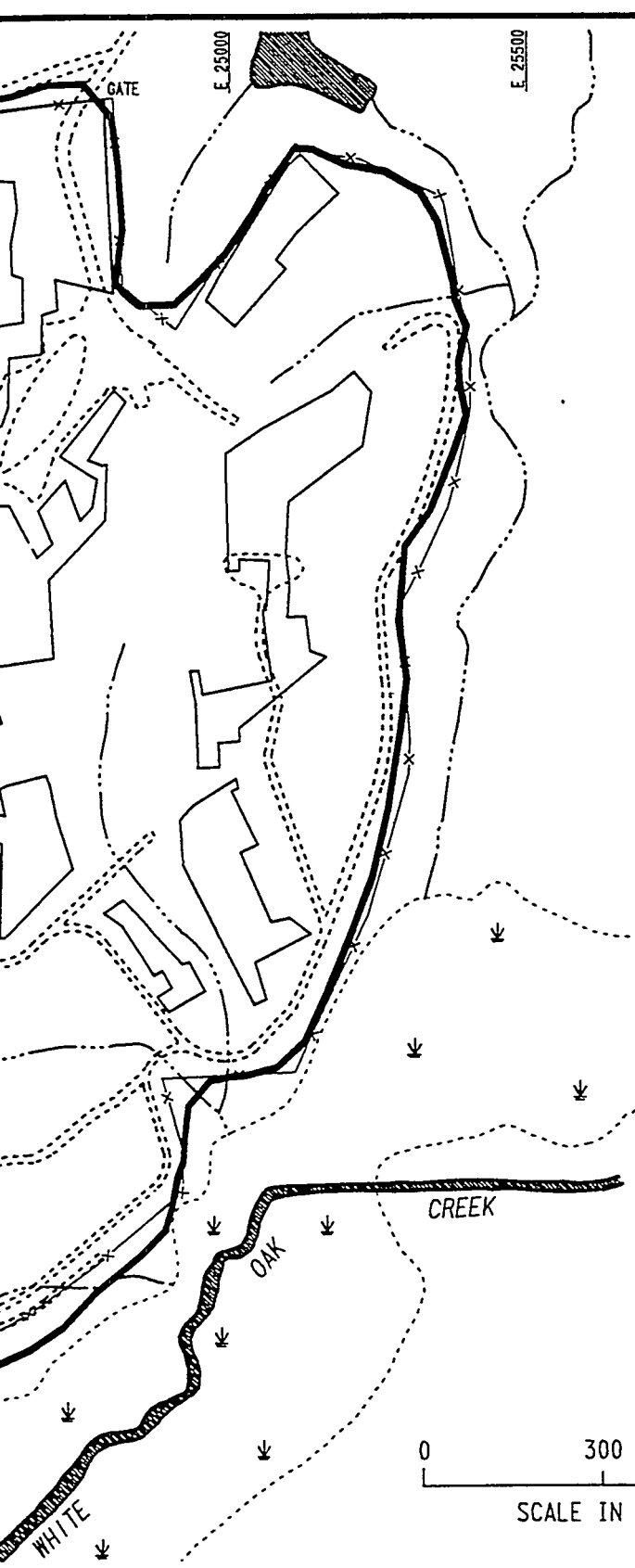
B = RFI SAMPLING
E = ORNL REGULATOR
COMPLIANCE MONITORING
RESULTS

LEGEND

- WAG 6 BOUNDARY
- - - - - TRIBUTARY
- x - SWSA SECURITY FENCE
- - - - - GRAVEL ROAD
- ▭ WASTE AREA
- ← POTENTIAL CONTAMINANT MIGRATION
- ◆ T135 — SAMPLE DESIGNATION
3,C — RANGE OF CONCENTRATION, SOURCE OF DATA
- GROUNDWATER SAMPLE
- ◆ SURFACE WATER SAMPLE
- ◆ SOIL BORING

FIGURE 5-10
DISTRIBUTION OF CHLOROFORM





NOTES

1. ALL UNITS IN UG/L.
2. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS. FT.
3. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
4. THE RANGES OF CONCENTRATIONS INDICATED ARE AS FOLLOWS:

1 =	1 - 9.9
2 =	10 - 99
3 =	100 - 999
4 =	1000 - 9999
5 =	10,000 - 99,999

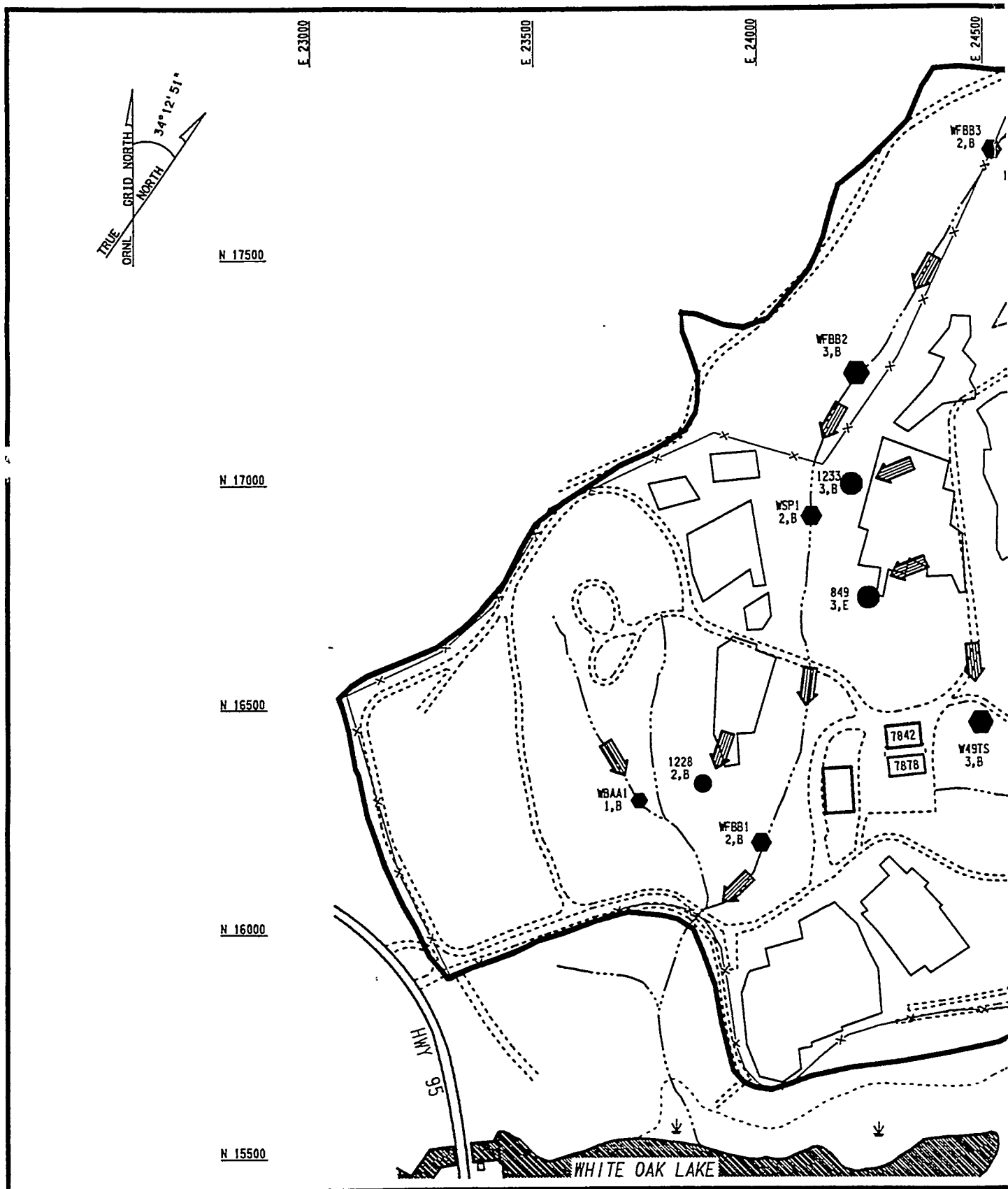
5. THE SOURCES OF DATA ARE AS FOLLOWS:

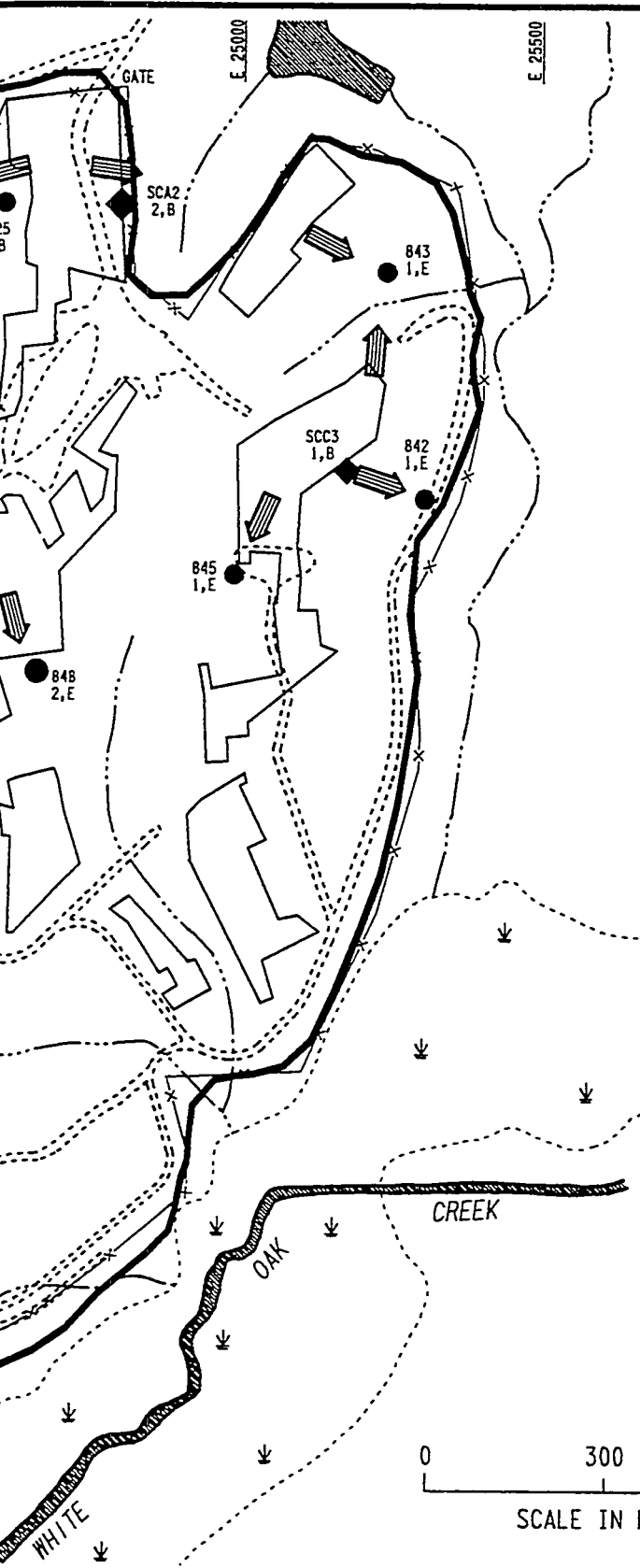
B = RFI SAMPLING
 E = ORNL REGULATORY COMPLIANCE MONITORING RESULTS

LEGEND

- WAG 6 BOUNDARY
- - - - - TRIBUTARY
- x - SWSA SECURITY FENCE
- - - - - GRAVEL ROAD
- ▭ WASTE AREA
- ← POTENTIAL CONTAMINANT MIGRATION
- ¹³⁵ — SAMPLE DESIGNATION
- _{3,C} — RANGE OF CONCENTRATION, SOURCE OF DATA
- GROUNDWATER SAMPLE

FIGURE 5-11
 DISTRIBUTION OF VINYL CHLORIDE





NOTES

1. ALL SURFACE WATER, GROUNDWATER, AND LEACHATE CONCENTRATIONS IN UG/L.
2. ALL SOIL CONCENTRATIONS IN UG/KG.
3. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
4. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
5. THE RANGES OF CONCENTRATION INDICATED ARE AS FOLLOWS:

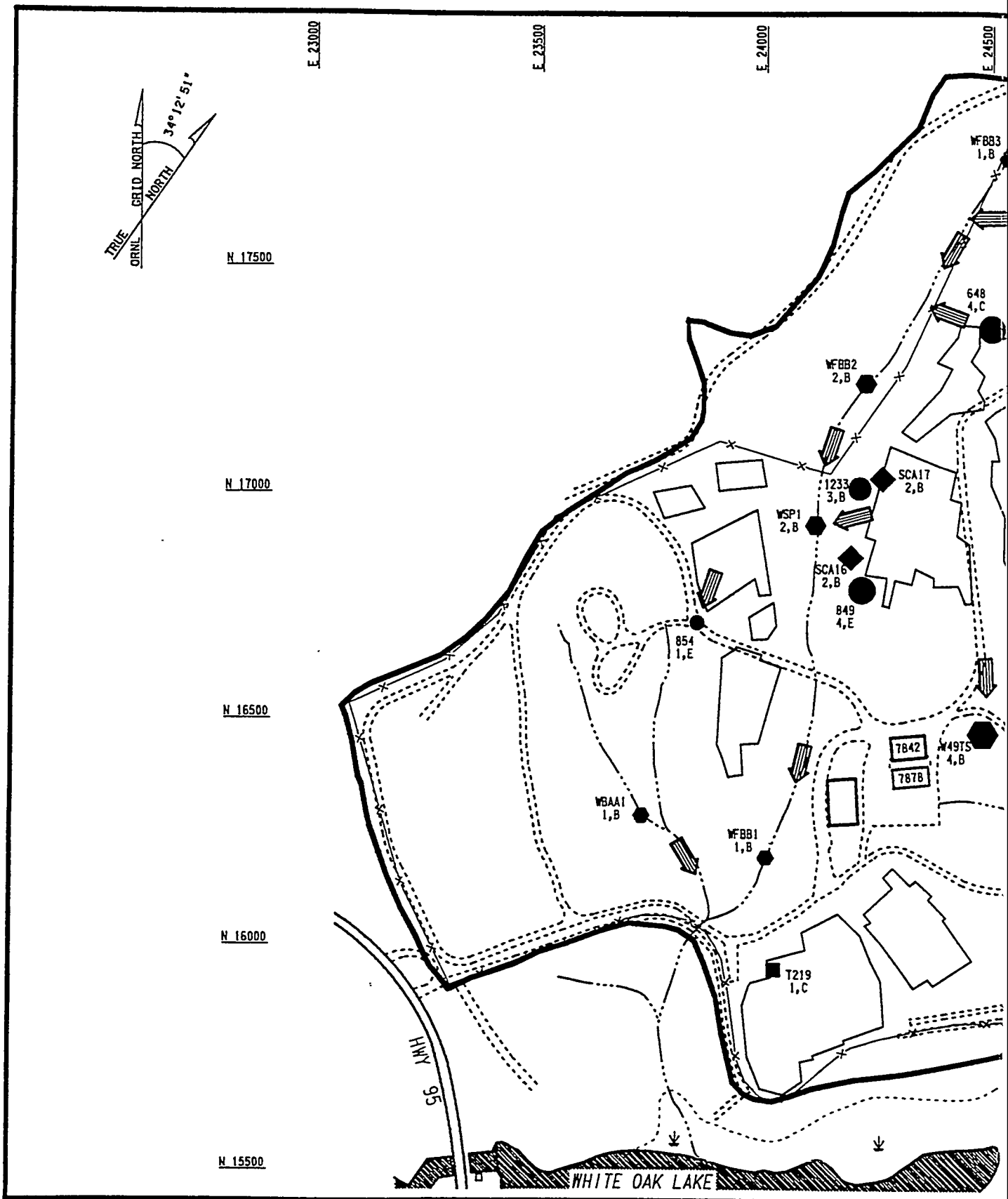
1 =	1 - 9.9
2 =	10 - 99
3 =	100 - 999
4 =	1000 - 9,999
5 =	10,000 - 99,999
6. THE SOURCES OF DATA ARE AS FOLLOWS:

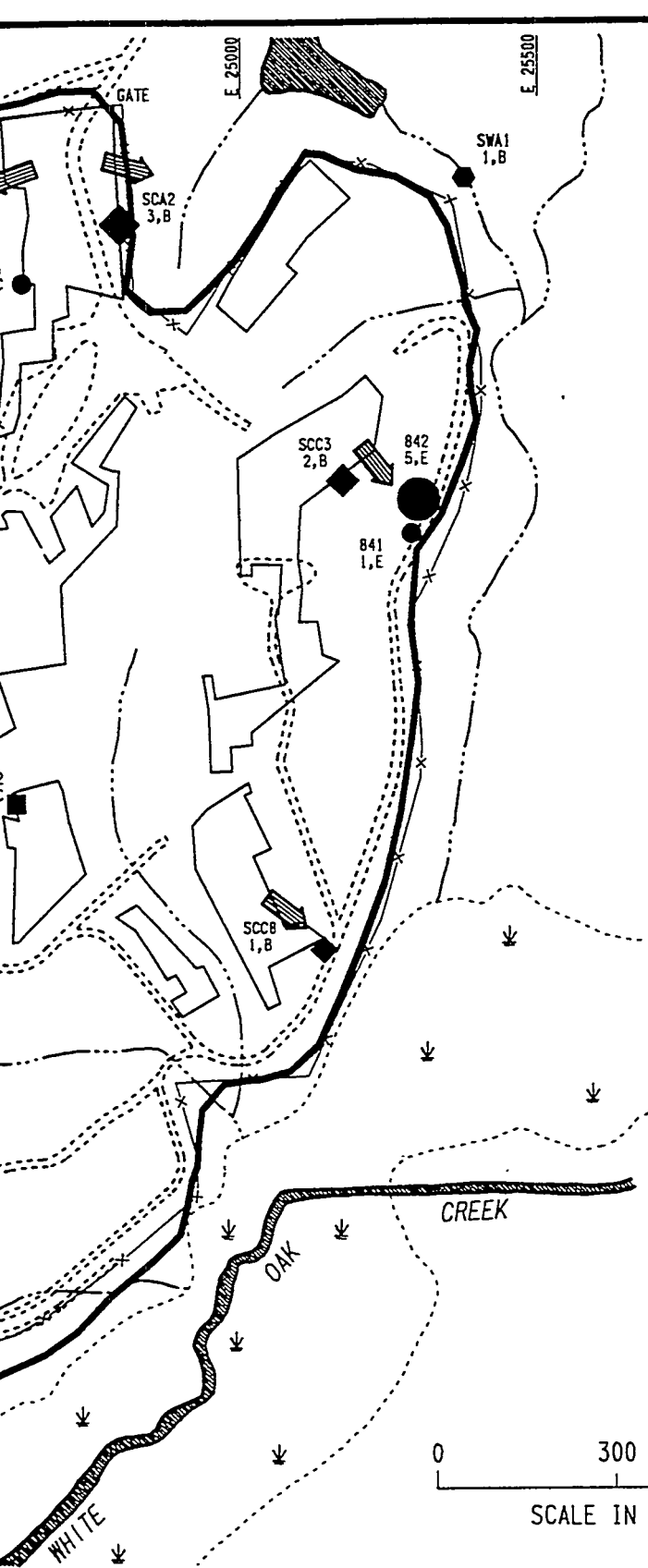
B =	RFI SAMPLING
E =	ORNL REGULATORY COMPLIANCE MONITORING RESULTS

LEGEND

- WAG 6 BOUNDARY
- TRIBUTARY
- x SWSA SECURITY FENCE
- GRAVEL ROAD
- WASTE AREA
- POTENTIAL CONTAMINANT MIGRATION
- 135
3,C SAMPLE DESIGNATION
- RANGE OF CONCENTRATION, SOURCE OF DATA
- GROUNDWATER SAMPLE
- SURFACE WATER SAMPLE
- SOIL BORING

FIGURE 5-12
DISTRIBUTION OF (1,2-DICHLOROETHENE





NOTES

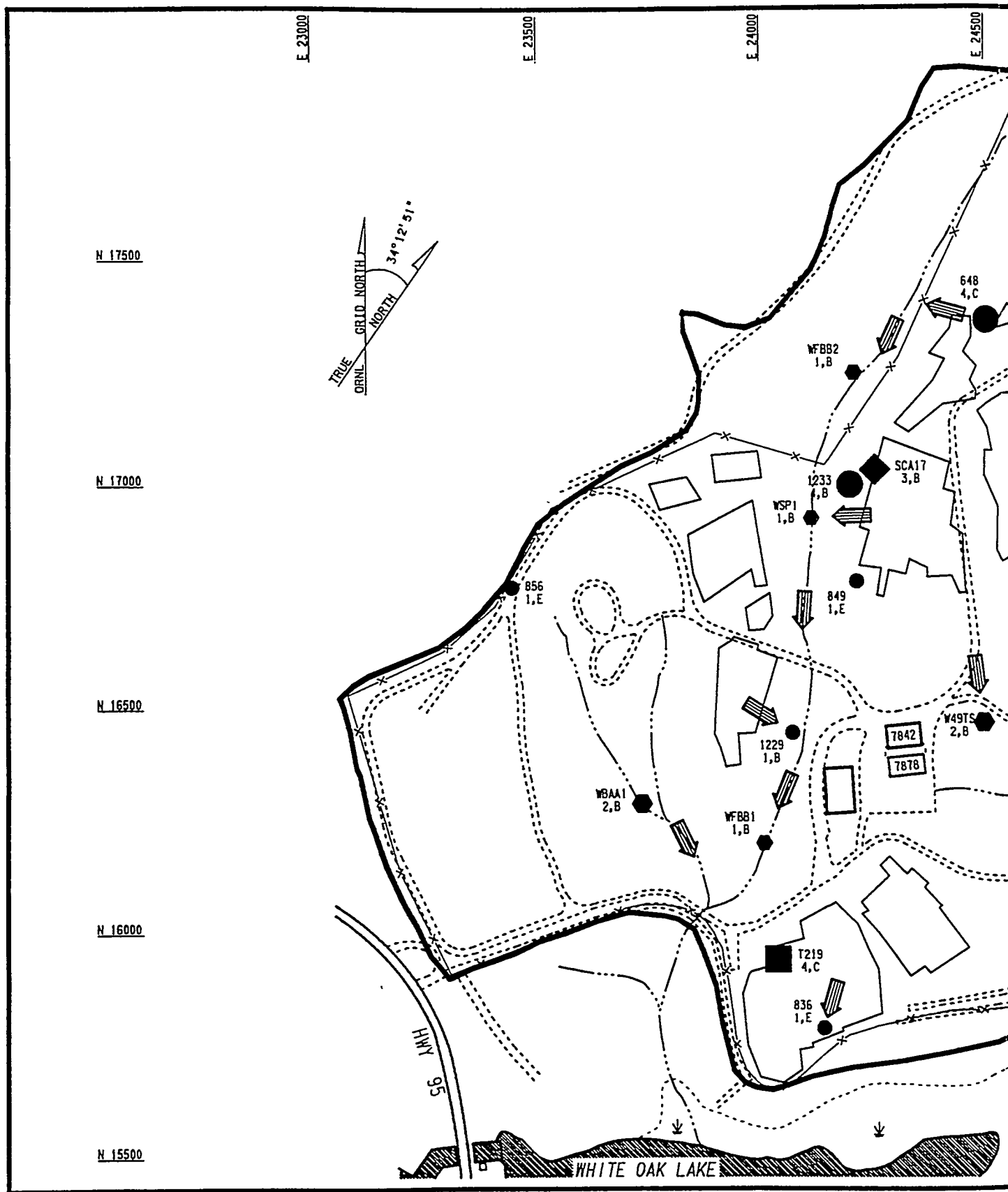
1. ALL SURFACE WATER, GROUNDWATER, AND LEACHATE CONCENTRATIONS IN UG/L.
2. ALL SOIL CONCENTRATIONS IN UG/KG.
3. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
4. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
5. THE RANGES OF CONCENTRATION INDICATED ARE AS FOLLOWS:

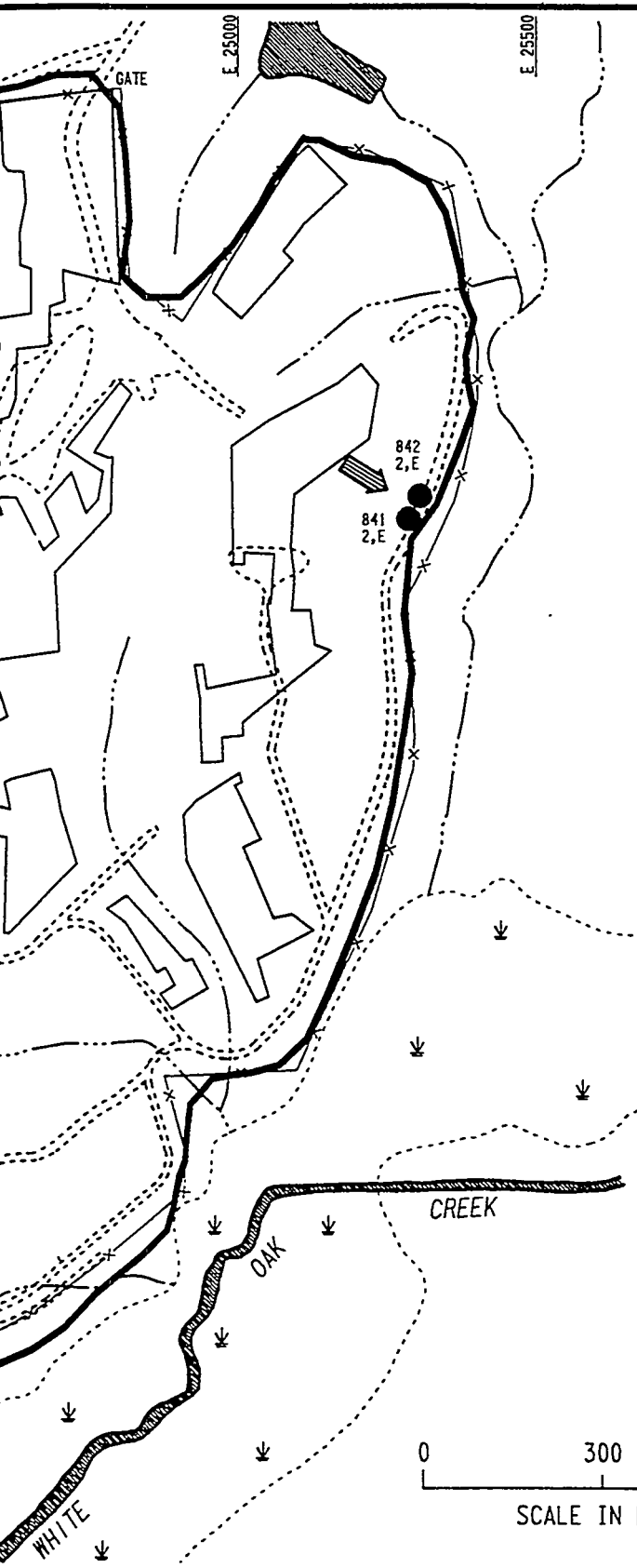
1 =	1 - 9.9
2 =	10 - 99
3 =	100 - 999
4 =	1000 - 9,999
5 =	10,000 - 99,999
6. THE SOURCES OF DATA ARE AS FOLLOWS:
 - B = RFI SAMPLING
 - C = SOLOMON, et al (1988)
 - E = ORNL REGULATORY COMPLIANCE MONITORING RESULTS

LEGEND

- WAG 6 BOUNDARY
- - - - - TRIBUTARY
- x - SWSA SECURITY FENCE
- - - - - GRAVEL ROAD
- ▨ WASTE AREA
- ← POTENTIAL CONTAMINANT MIGRATION
- T135 — SAMPLE DESIGNATION
- 3,C — RANGE OF CONCENTRATION, SOURCE OF DATA
- GROUNDWATER SAMPLE
- ▨ TRENCH LEACHATE SAMPLE
- SURFACE WATER SAMPLE
- ◆ SOIL BORING

FIGURE 5-13
DISTRIBUTION OF TRICHLOROETHENE





NOTES

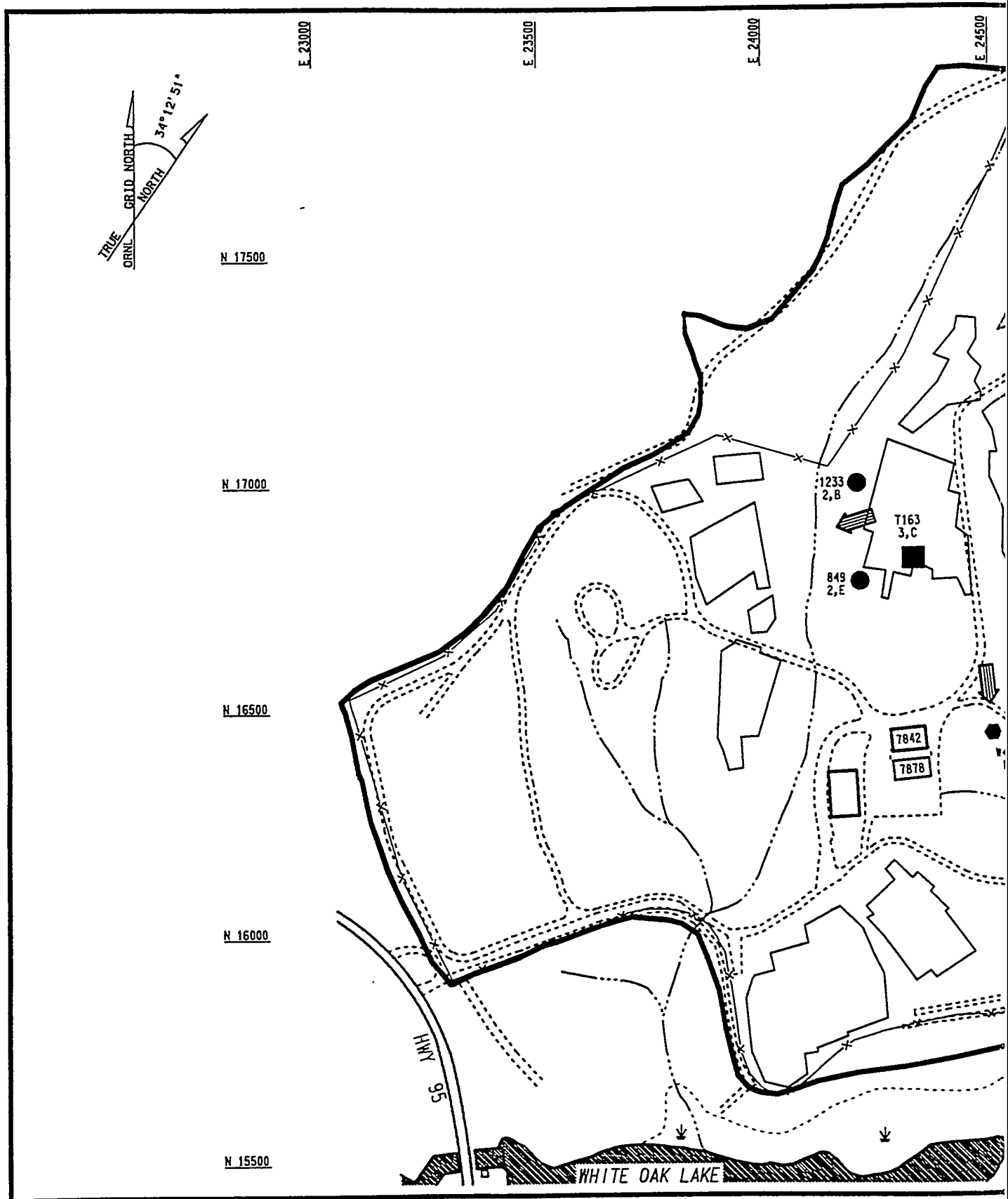
1. ALL SURFACE WATER, GROUNDWATER, AND LEACHATE CONCENTRATIONS IN UG/L.
2. ALL SOIL CONCENTRATIONS IN UG/.KG.
3. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
4. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
5. THE RANGES OF CONCENTRATION INDICATED ARE AS FOLLOWS:

1 =	1 - 9.9
2 =	10 - 99
3 =	100 - 999
4 =	1000 - 9,999
5 =	10,000 - 99,999
6. THE SOURCES OF DATA ARE AS FOLLOWS:
 - B = RFI SAMPLING
 - C = SOLOMON, et al (1988)
 - E = ORNL REGULATORY COMPLIANCE MONITORING RESULTS

LEGEND

- WAG 6 BOUNDARY
- - - - - TRIBUTARY
- x- SWSA SECURITY FENCE
- - - - - GRAVEL ROAD
- ▬ WASTE AREA
- ← POTENAL CONTAMINANT MIGRATION
- T135 — SAMPLE DESIGNATION
- 3,C — RANGE OF CONCENTRATION, SOURCE OF DATA
- GROUNDWATER SAMPLE
- TRENCH LEACHATE SAMPLE
- SURFACE WATER SAMPLE
- ◆ SOIL BORING

FIGURE 5-14
DISTRIBUTION OF TETRACHLOROETHEN



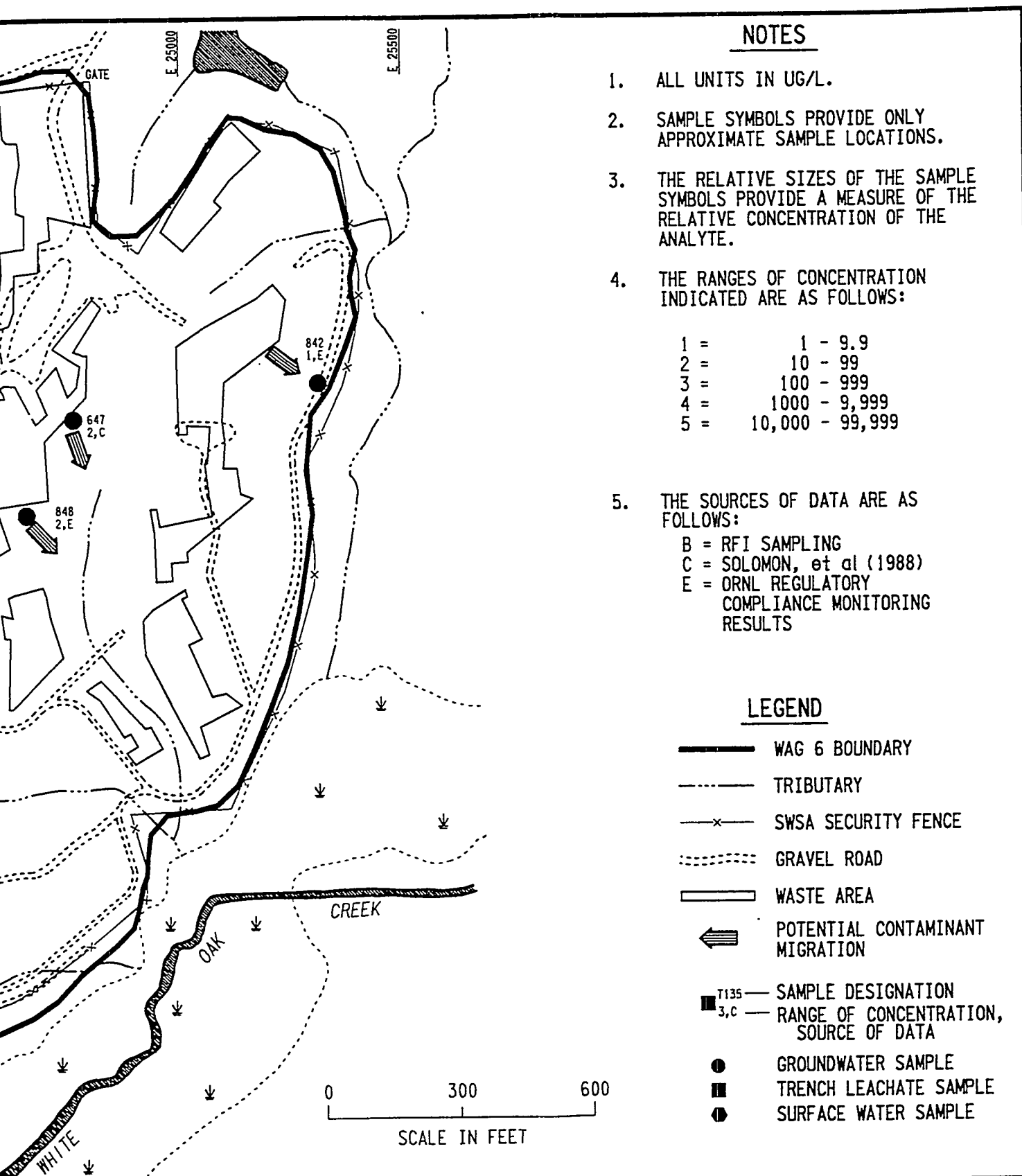
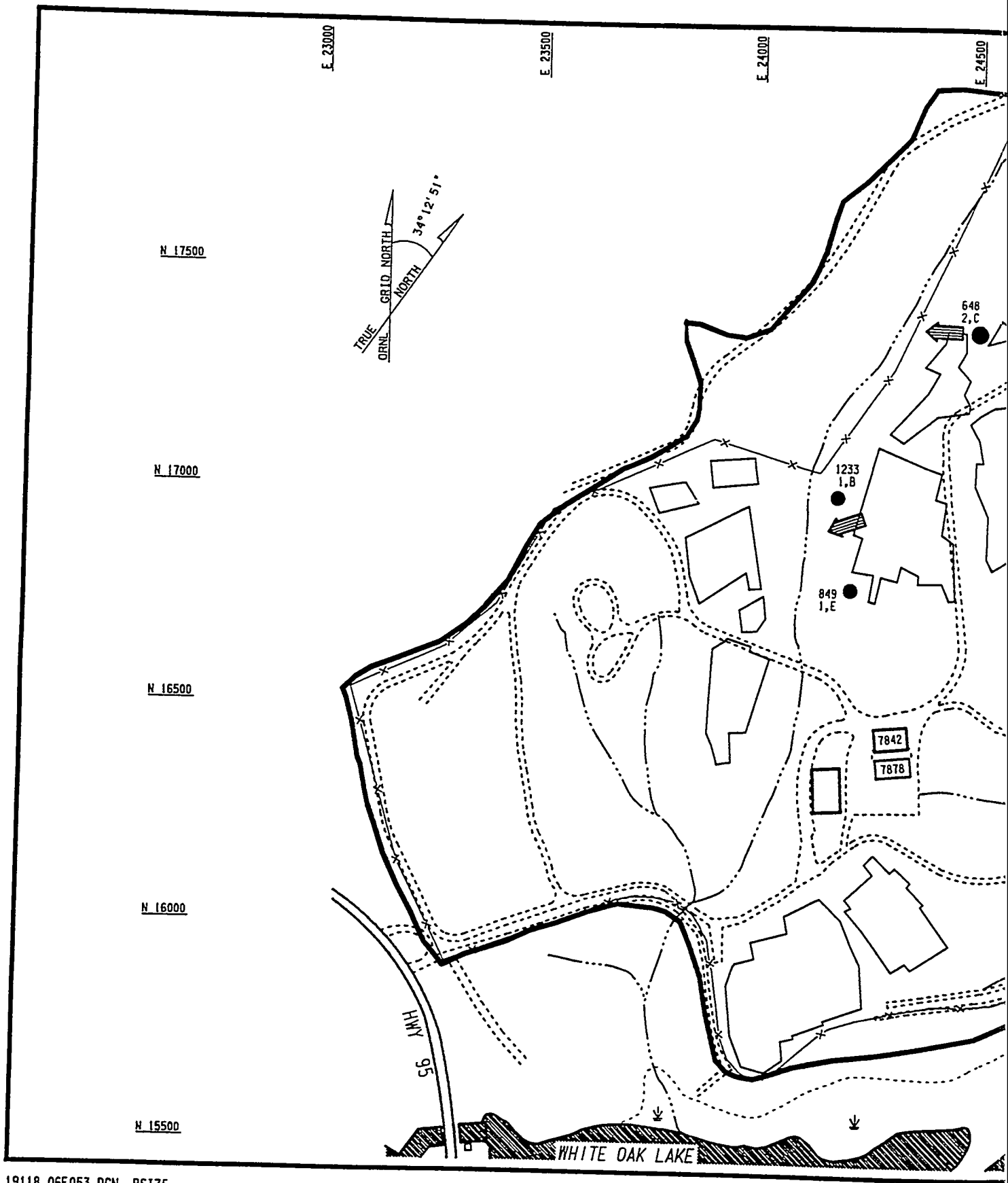


FIGURE 5-15
DISTRUBUTION OF 1, 1-DICHLOROETHANE



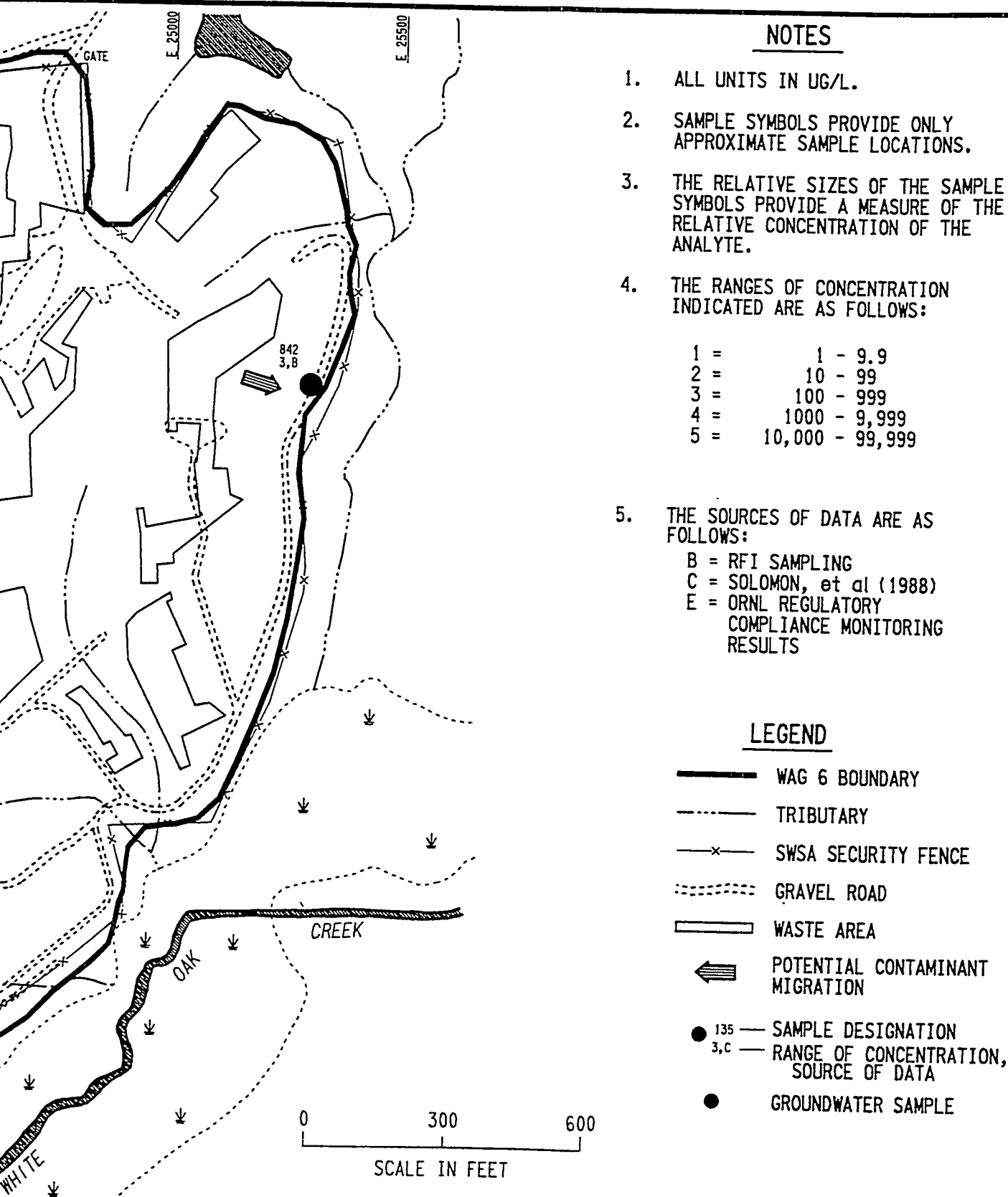
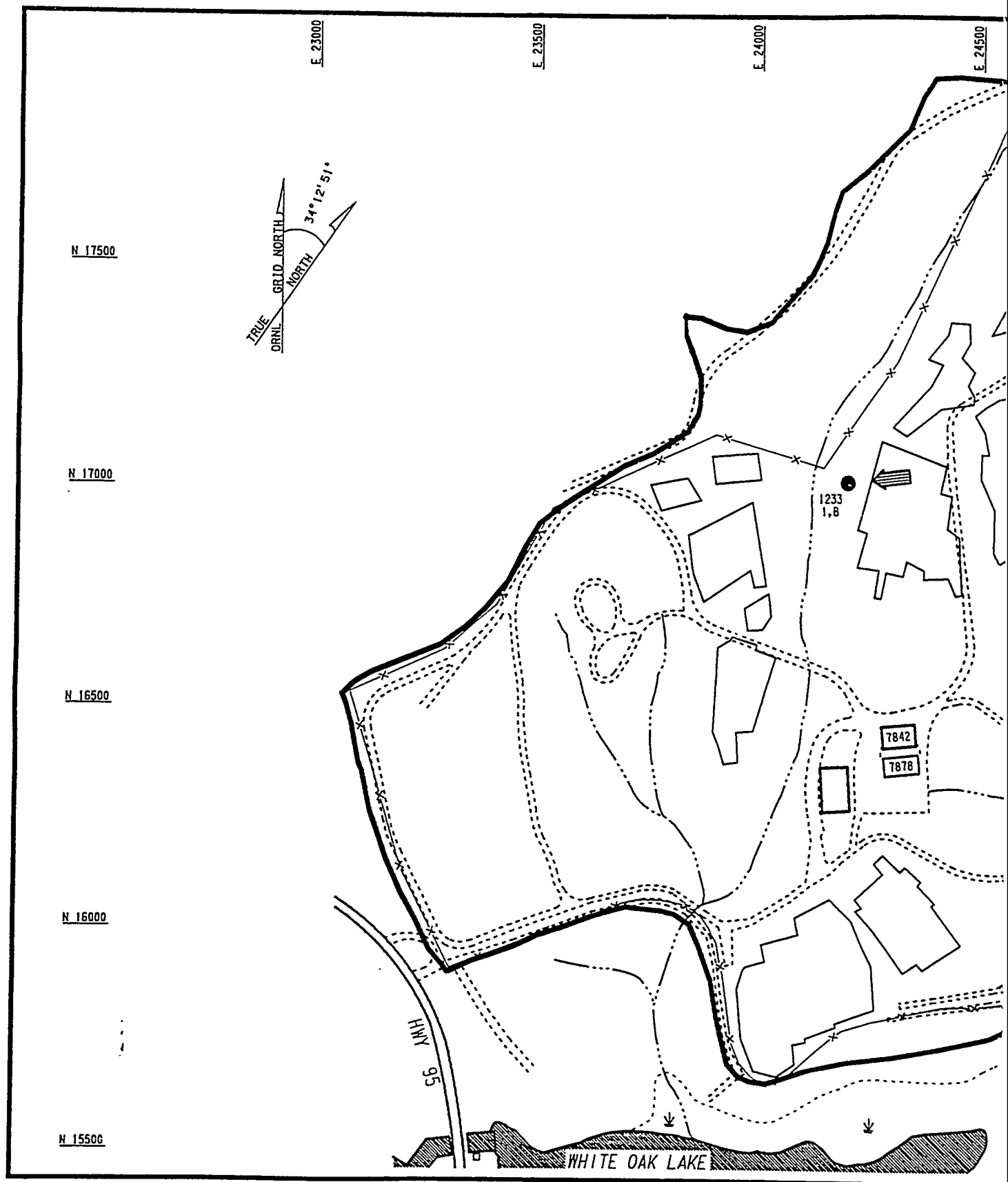
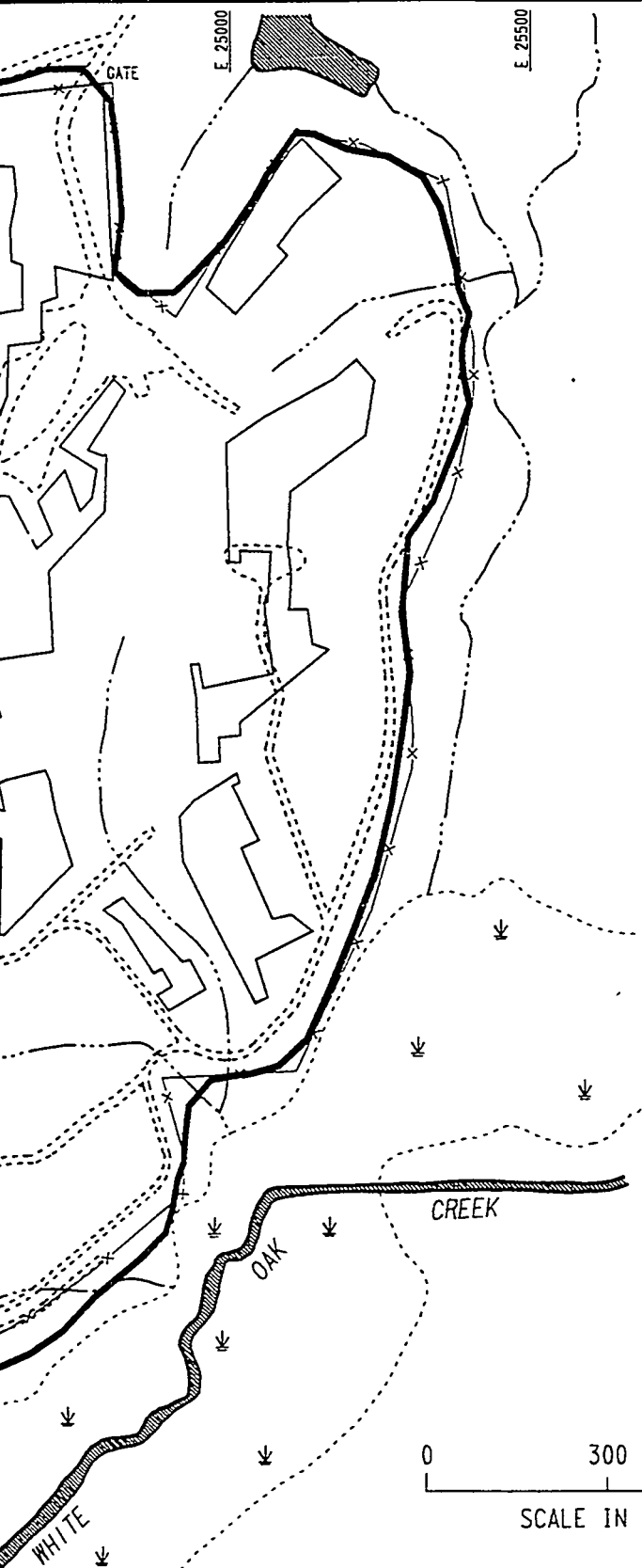


FIGURE 5-16
DISTRIBUTION OF 1, 2-DICHLOROETHANE





NOTES

1. ALL UNITS IN UG/L.
2. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
3. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
4. THE RANGES OF CONCENTRATION INDICATED ARE AS FOLLOWS:

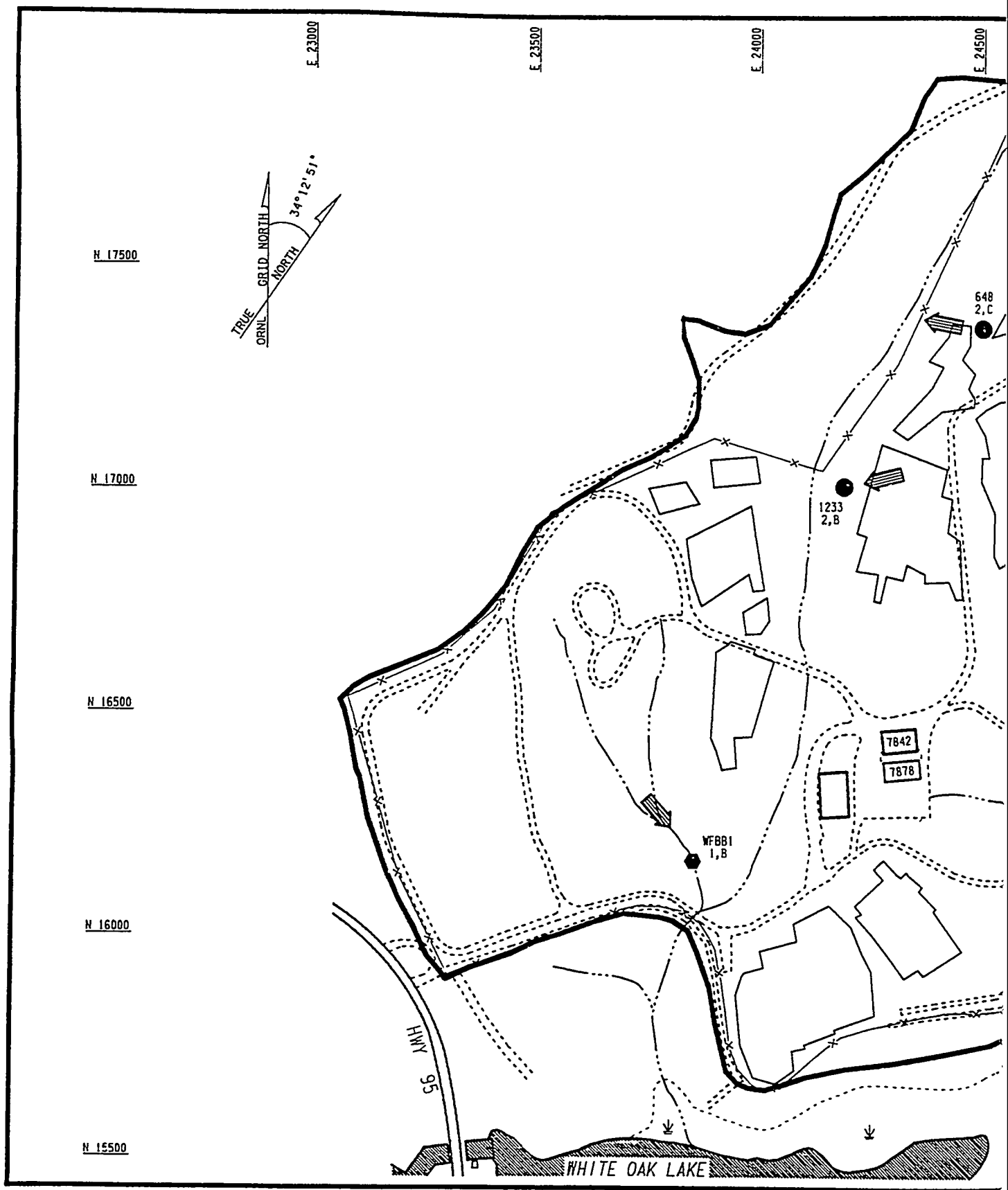
1 =	1 - 9.9
2 =	10 - 99
3 =	100 - 999
4 =	1000 - 9,999
5 =	10,000 - 99,999
5. THE SOURCES OF DATA ARE AS FOLLOWS:

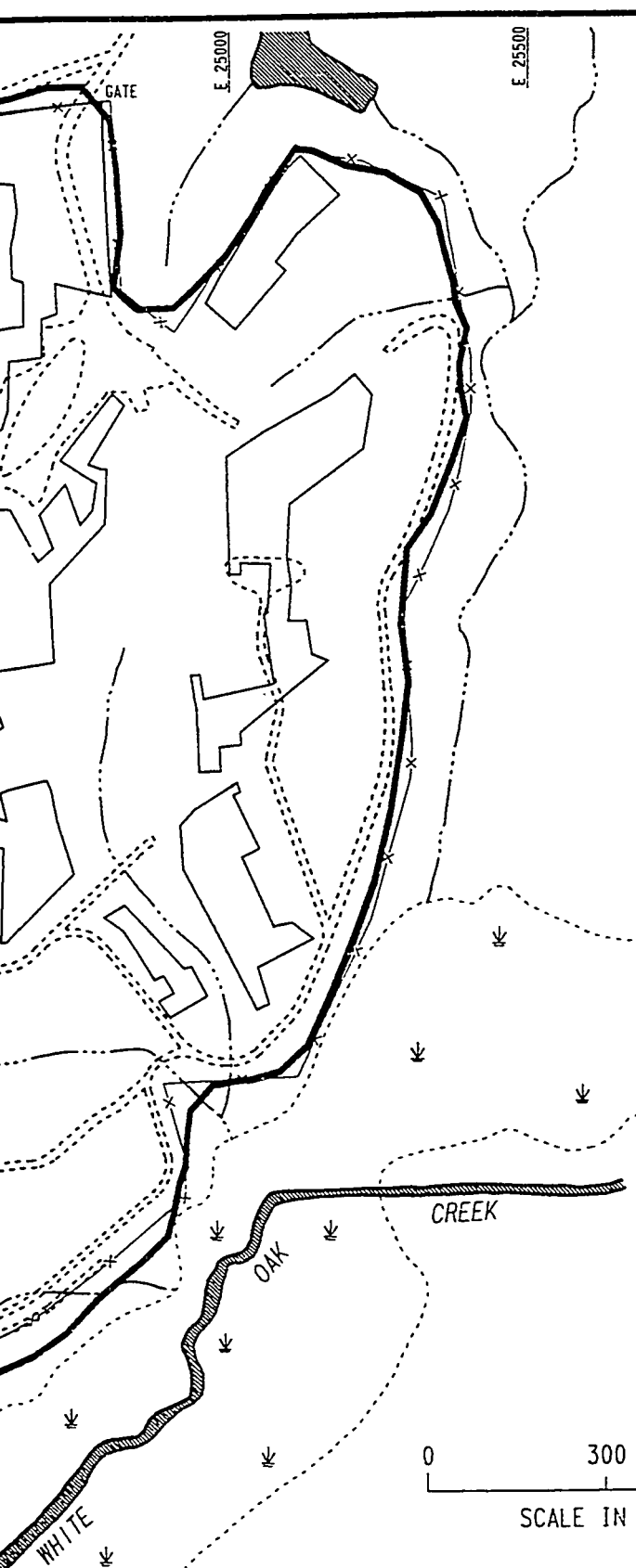
B = RFI SAMPLING

LEGEND

- WAG 6 BOUNDARY
- TRIBUTARY
- x SWSA SECURITY FENCE
- GRAVEL ROAD
- WASTE AREA
- POTENTIAL CONTAMINANT MIGRATION
- 135 — SAMPLE DESIGNATION
- 3,C — RANGE OF CONCENTRATION, SOURCE OF DATA
- GROUNDWATER SAMPLE

FIGURE 5-17
DISTRIBUTION OF
1, 1, 2-TRICHLOROETHANE





NOTES

1. ALL UNITS IN UG/L.
2. SAMPLE SYMBOLS PROVIDE ONLY SHOWN APPROXIMATE SAMPLE LOCATIONS.
3. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
4. THE RANGES OF CONCENTRATION INDICATED ARE AS FOLLOWS:

1 =	1 - 9.9
2 =	10 - 99
3 =	100 - 999
6 =	1000 - 9,999
5 =	10,000 - 99,999

5. THE SOURCES OF DATA ARE AS FOLLOWS:

B = RFI SAMPLING
C = SOLOMON, et al (1988)

LEGEND

- WAG 6 BOUNDARY
- - - - - TRIBUTARY
- x - SWSA SECURITY FENCE
- - - - - GRAVEL ROAD
- ▭ WASTE AREA
- ← POTENTIAL CONTAMINANT MIGRATION
- 135 — SAMPLE DESIGNATION
- 3,C — RANGE OF CONCENTRATION, SOURCE OF DATA
- GROUNDWATER SAMPLE
- SURFACE WATER SAMPLE

FIGURE 5-18
DISTRIBUTION OF
1, 1, 2, 2-TETRACHLOROETHANE
5-51

in Well 842 on the WAG boundary. Elsewhere on the site, chloroform was detected at levels less than 10 ppb, far below the human health criteria stated above.

Carbon Tetrachloride. Carbon tetrachloride was detected at only one location, in Well 842 at a maximum concentration of 97 ppb. By comparison, the human health criterion identified in Section 7.0 is 5 ppb. Well 842 is located at the eastern perimeter of the WAG, downslope of solvent auger hole group. The data indicates off-site migration from the solvent auger holes.

Vinyl Chloride. Vinyl chloride was detected at two groundwater sampling locations, both located on the western perimeter of the 49-trench area (Figure 5-11); 79 ppb were detected in Well 1233 and 63 ppb in Well 849. For comparison, the SDWA MCL for vinyl chloride is 2 ppb. The data indicate migration of vinyl chloride in groundwater from the 49-trench area downslope to the west.

1,2-Dichloroethene. 1,2-Dichloroethene was detected at nine groundwater sampling locations, five surface water sampling locations, and two soil sampling locations at WAG 6 (Figure 5-12). There are two isomers of 1,2-dichloroethene: cis- and trans-; however, the data reported by the laboratory for this compound do not distinguish isomers. The human health criteria developed in Section 7.0 for the cis- and trans- isomers of 1,2-dichloroethene are 7 ppb and 100 ppb, respectively. The values reported for 1,2-dichloroethene exceed the criteria for the cis- isomer (7 ppb) at 11 of the groundwater and surface water sampling locations, and exceed the criteria for the trans- isomer (100 ppb) at 4 of the locations.

The highest levels of 1,2-dichloroethene are associated with the central disposal area. It was detected in four groundwater samples, 4 surface water samples, and one soil sample around the perimeter of this area. Source areas within the central disposal

area appear to be the high-activity trench area at the north, the 49-trench area, and the group of low-activity trenches to the east of the 49-trench area.

In the east disposal area, 1,2-dichloroethene was detected in soil boring SCC3, located adjacent to the solvent auger hole area. It was also detected in Wells 842 and 843, located downslope of the solvent auger hole area, indicating migration of the compound from the solvent auger holes.

Trichloroethene (TCE). TCE was detected in seven groundwater sampling locations, seven surface water sampling locations, and five soil sampling locations (Figure 5-13). At most of the groundwater and surface water sample locations where TCE was detected, the levels exceeded the SDWA MCL of 5 ppb. No human health criteria were developed for TCE in Section 7.0.

Most of the locations where TCE was detected were located along the western perimeter of the central disposal area. The locations in which TCE was detected indicate that the compound is being released from the high-activity trenches at the north, the solvent auger hole area just to the north of the 49-trench area (see Figure 5-9), and the 49-trench area. The highest levels in the central disposal area are associated with the solvent auger hole area (2323 ppb in Well 648) and the 49-trench area (480 ppb in Well 1233, 1300 ppb in Well 849, and 2200 ppb at the outlet to the 49-trench drain).

High levels are also being released from the solvent auger hole area located in the northern portion of the east disposal area. This is evidenced by 16 ppb in soil boring SCC3, located on the perimeter of the solvent auger hole area, and by levels of 51,000 and 19 ppb in Wells 842 and 841, respectively. (Well 842 is a shallow well and Well 841 is a deep well.)

Tetrachloroethene (PCE). PCE was detected in seven groundwater sampling locations, five surface water sampling locations, and two soil sampling locations (Figure 5-14). Levels in water exceeded the drinking water health advisory of 1,000 ppb (see Section 7.0) at only two locations. Levels of TCE detected in soil were approximately two orders of magnitude less than the human health criteria developed in Section 7.0 for PCE in soil (14,000 ppb) in Section 7.0.

Similar to the pattern described for 1,2-dichloroethene and TCE, most of the PCE detects were located along the western perimeter of the central disposal area. The locations in which PCE was detected indicate that the compound is being released from the solvent auger hole area just to the north of the 49-trench area (1,973 ppb in Well 648) and from the 49-trench area itself (6,800 ppb in Well 1233). These are the two locations at which the health advisory for drinking water was exceeded.

In the east disposal area, PCE appears to be migrating from the solvent auger hole area. This is indicated by levels of 16 and 14 ppb in Wells 841 and 842, respectively. Elsewhere on the site, levels of PCE detected in water are generally less than 10 ppb. The exception is surface water sampling location WBAA1 where PCE was detected at a maximum level of 70 ppb. This location is downstream of the ETF facility.

1,1-Dichloroethane. 1,1-Dichloroethane was detected at five groundwater sampling locations and one surface water sampling location (Figure 5-15). The levels detected ranged from 6 to 23 ppb; all exceeded the human health criteria of 0.4 ppb developed in Section 7.0.

The detects indicate three source areas: the 49-trench area, the low-activity trench group and solvent auger hole group to the east of the 49-trench area, and the solvent auger hole group at the north end of the east disposal area. A trench leachate

sample collected by Solomon et al. (1988) from the 49-trench area showed 626 ppb, which further indicates that the 49-trench area is a source area for this compound.

1,2-Dichloroethane. 1,2-Dichloroethane was detected at four groundwater sampling locations and one surface water sampling location (Figure 5-16). The levels detected ranged from 2 to 24 ppb. The SDWA MCL of 5 ppb was exceeded at only two groundwater locations.

The detects indicate three source areas of 1,2-dichloroethane: the 49-trench area, the solvent auger hole group to the north of the 49-trench area, and the solvent auger hole group at the north end of the east disposal area. The levels exceeding the SDWA MCL were found at Well 648 (23 ppb), located downslope of the solvent auger hole area to the north of the 49-trench area, and at Well 842 (24 ppb), located downslope of the solvent auger hole area at the north end of the east disposal area.

1,1,2-Trichloroethane. 1,1,2-Trichloroethane was detected at only one location, in Well 1233 at a concentration of 3 ppb (Figure 5-17). By comparison, the human health criteria developed in Section 7.0 is 0.6 ppb. Well 1233 is located on the western perimeter of the 49-trench area.

1,1,2,2-Tetrachloroethane. 1,1,2,2-Tetrachloroethane was detected at two groundwater sampling locations and one surface water sampling location (Figure 5-18). The levels detected ranged from 1 to 55 ppb. The human health standard for drinking water developed in Section 7.0 (1.8 ppb) was exceeded at both groundwater locations.

The groundwater detects indicate two source areas of 1,1,2,2-tetrachloroethane: the 49-trench area and the solvent auger hole group to the north of the 49-trench area. In Well 1233, located on the western perimeter of the 49-trench area, 44 ppb was

detected and 55 ppb was detected in Well 648, located downslope of the solvent auger hole area to the north of the 49-trench area.

Benzenes, Toluenes, and Xylenes

Five BTX compounds were detected during environmental sampling at WAG 6: benzene, ethylbenzene, chlorobenzene, toluene, and xylene. All BTX compounds except chlorobenzene were present at levels exceeding human health criteria for water. Chlorobenzene was detected at only one location in WAG 6, in soil boring SCC8 at 1 ppb. This concentration is many orders of magnitude less than the human health criteria developed in Section 7.0 for chlorobenzene in soil (1,600,000 ppb).

The distributions of compounds exceeding human health criteria are illustrated in the following series of figures:

Figure 5-19 (benzene)

Figure 5-20 (ethyl benzene)

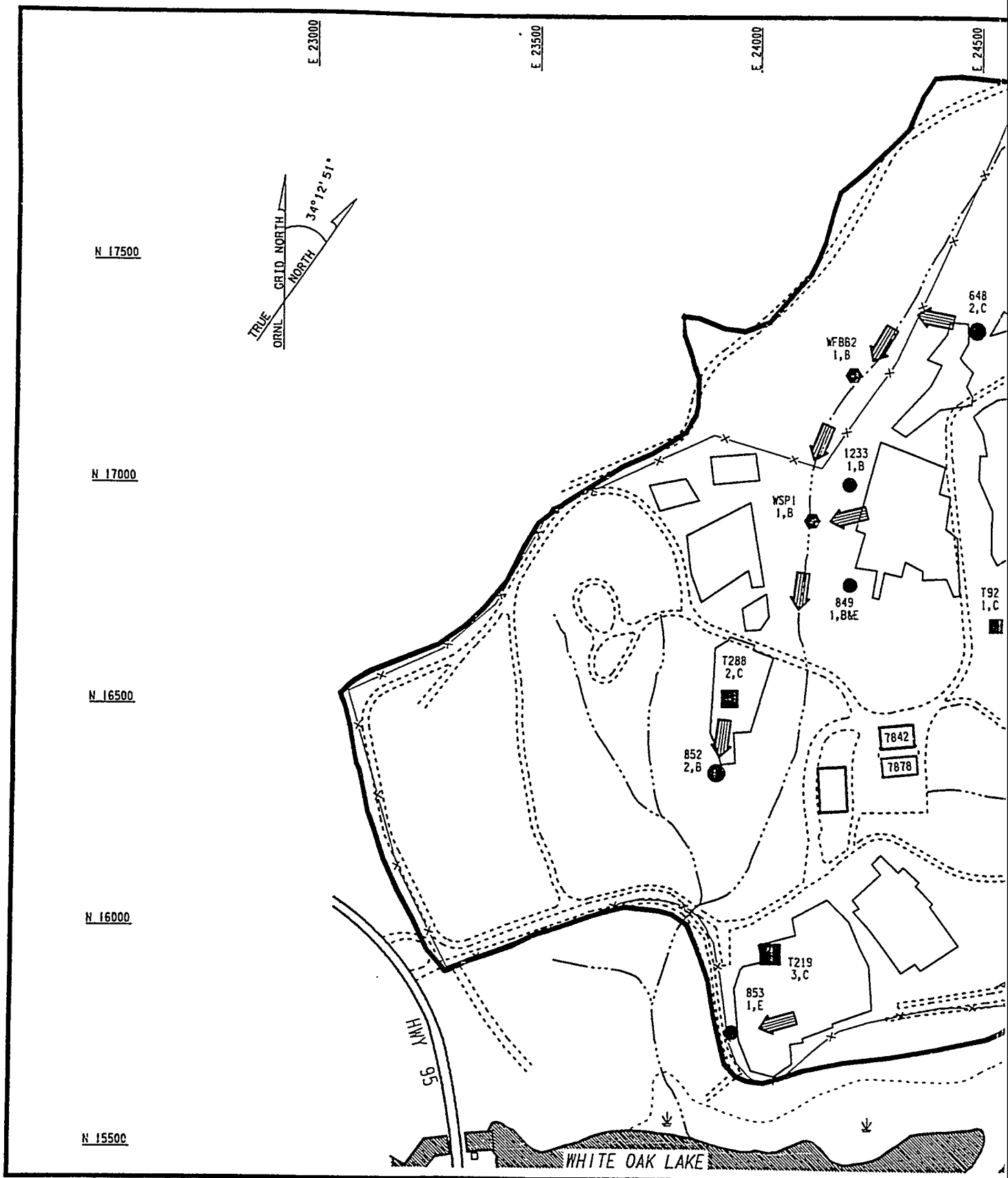
Figure 5-21 (toluene)

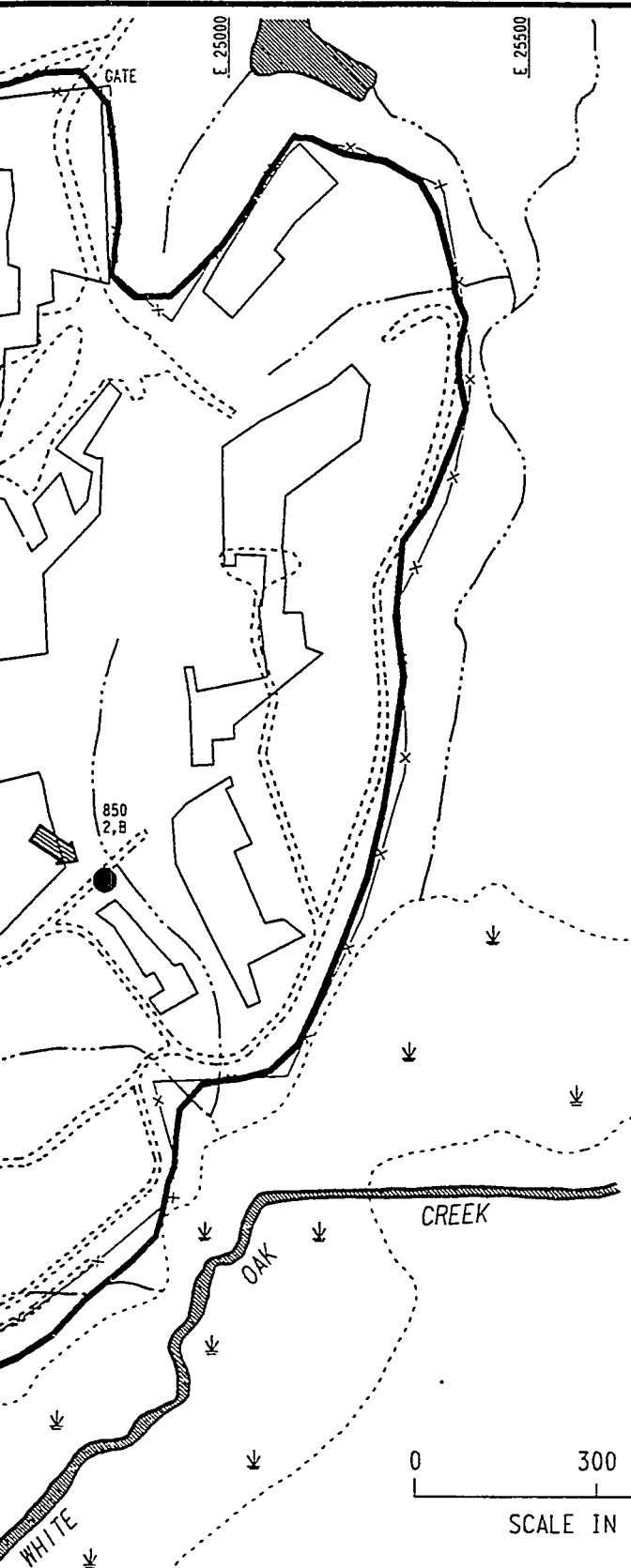
Figure 5-22 (xylene)

The following paragraphs briefly discuss the distribution of the BTX compounds detected at levels exceeding the human health criteria developed in Section 7.0.

Benzene. Benzene was detected at three trench leachate sampling locations, six groundwater sampling locations, and two surface water sampling locations (Figure 5-19). The levels in water exceeded the SDWA MCL of 5 ppb at two of the trench leachate locations and at four groundwater sampling locations.

The data indicate five trench and auger hole groups as sources of benzene release: 1) the solvent auger hole group north of the





NOTES

1. ALL UNITS IN UG/L.
2. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
3. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
4. THE RANGES OF CONCENTRATION INDICATED ARE AS FOLLOWS:

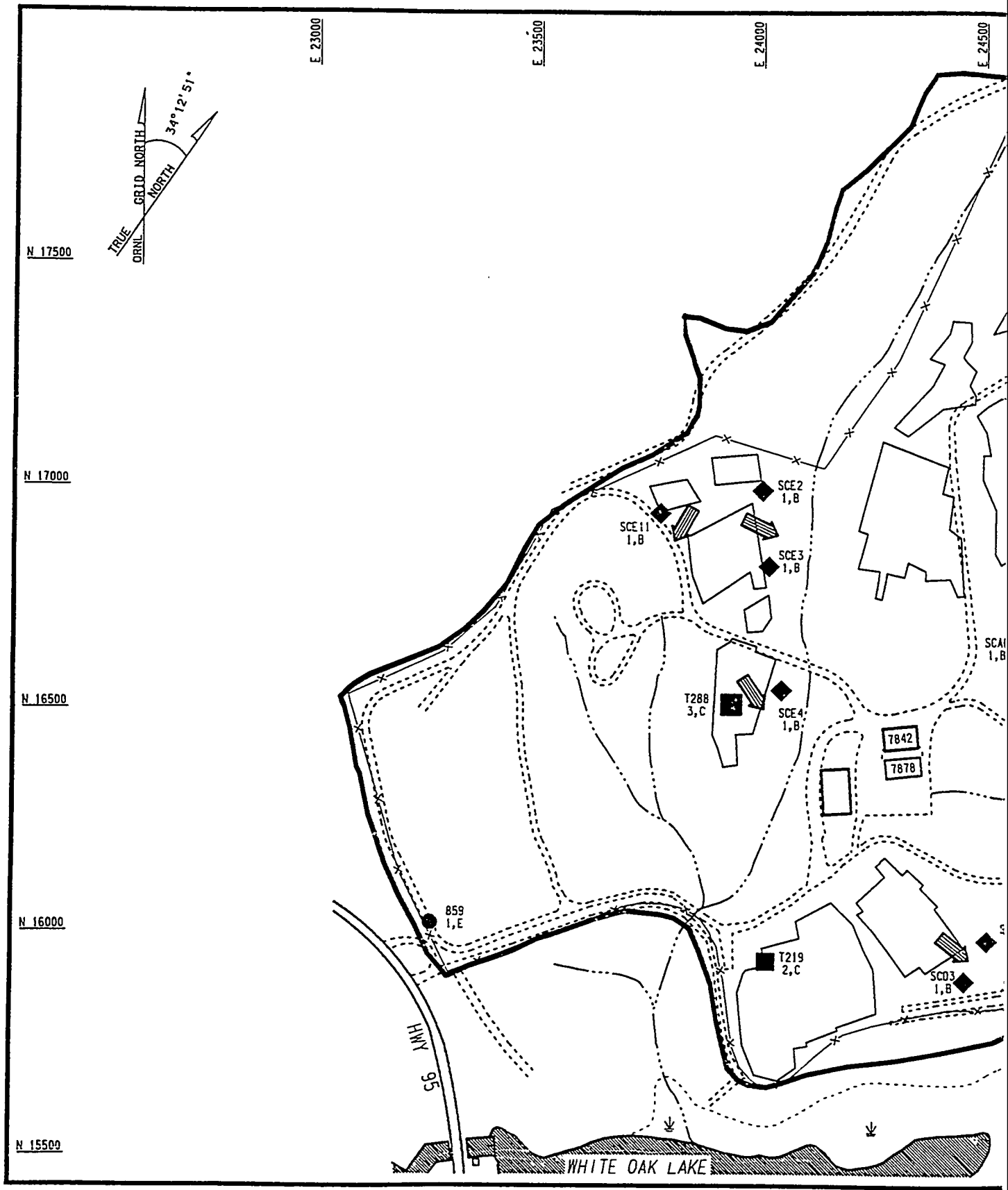
1 =	1 - 9.99
2 =	10 - 99.9
3 =	100 - 999
4 =	1000 - 9,999
5 =	10000 - 99,999
5. THE SOURCES OF DATA ARE AS FOLLOWS:

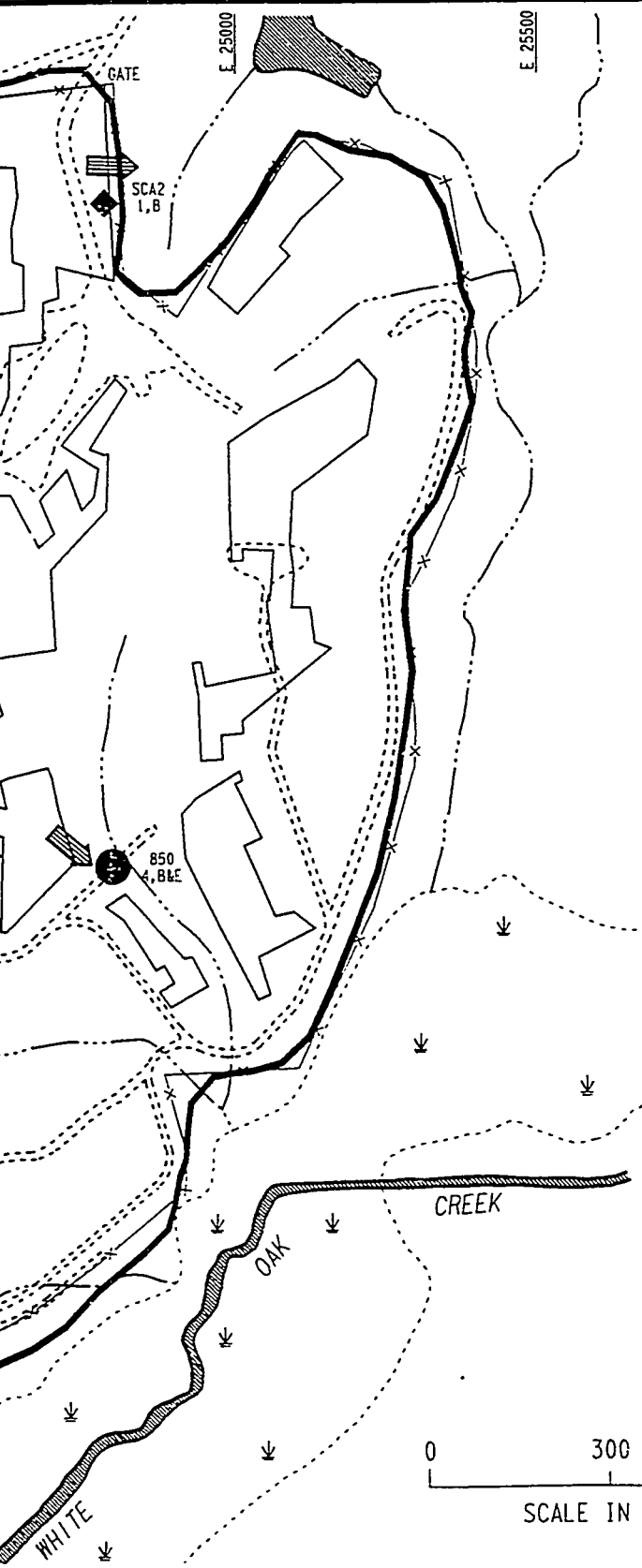
B =	RFI SAMPLING
C =	SOLOMON, et al (1988)
E =	ORNL REGULATORY COMPLIANCE MONITORING RESULTS

LEGEND

- WAG 6 BOUNDARY
- TRIBUTARY
- xx SWSA SECURITY FENCE
- GRAVEL ROAD
- WASTE AREA
- POTENTIAL CONTAMINANT MIGRATION
- T135 — SAMPLE DESIGNATION
- 3,C — RANGE OF CONCENTRATION, SOURCE OF DATA
- GROUNDWATER SAMPLE
- TRENCH LEACHATE SAMPLE
- SURFACE WATER SAMPLE

FIGURE 5-19
DISTRIBUTION OF BENZENE





NOTES

1. ALL SURFACE WATER, GROUNDWATER, AND LEACHATE CONCENTRATIONS IN UG/L.
2. SOIL CONCENTRATIONS IN UG/KG.
3. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
4. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
5. THE RANGES OF CONCENTRATION INDICATED ARE AS FOLLOWS:

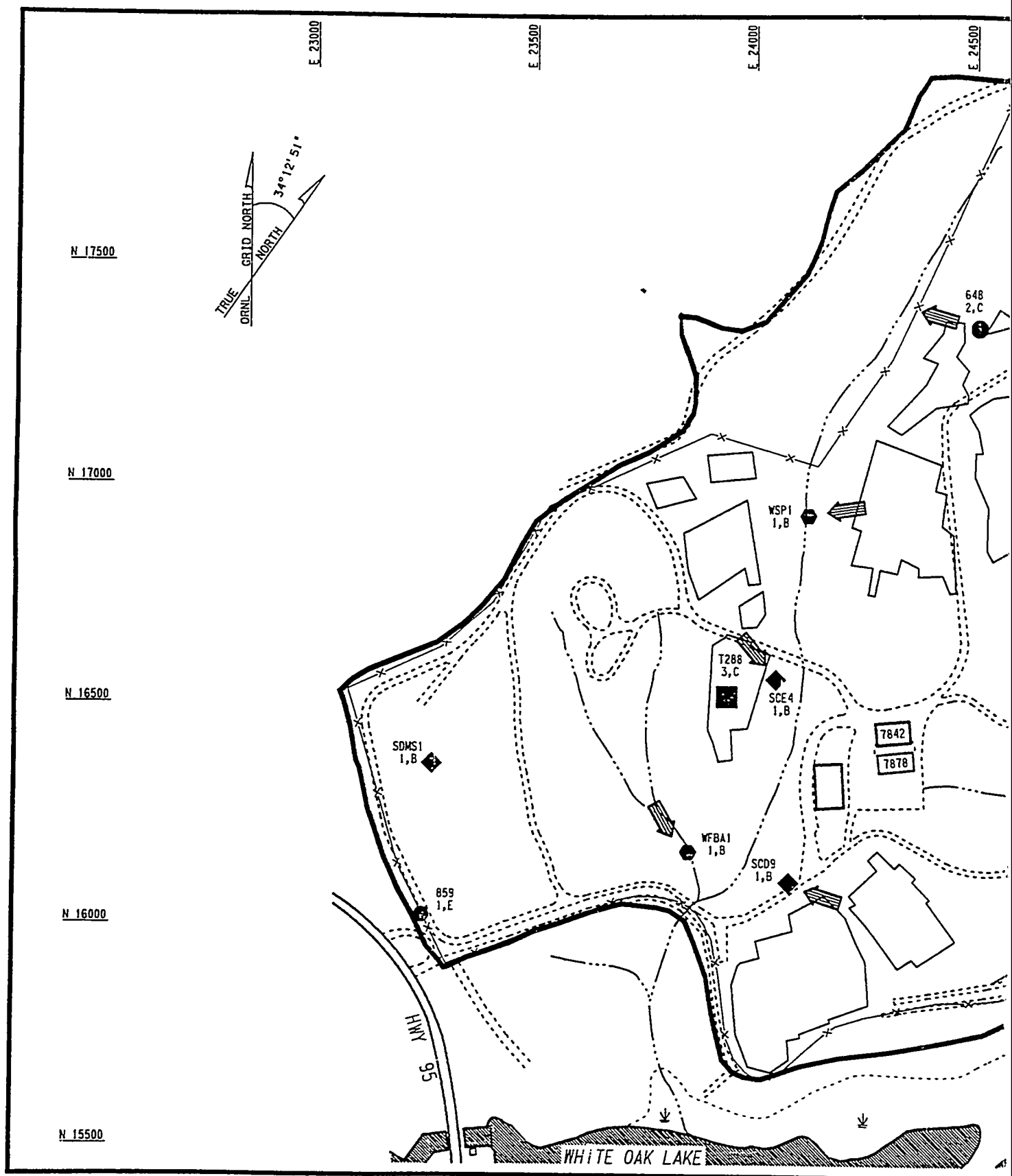
1 =	1 - 9.9
2 =	10 - 99
3 =	100 - 999
4 =	1000 - 9999
5 =	10,000 - 99,999
6. THE SOURCES OF DATA ARE AS FOLLOWS:

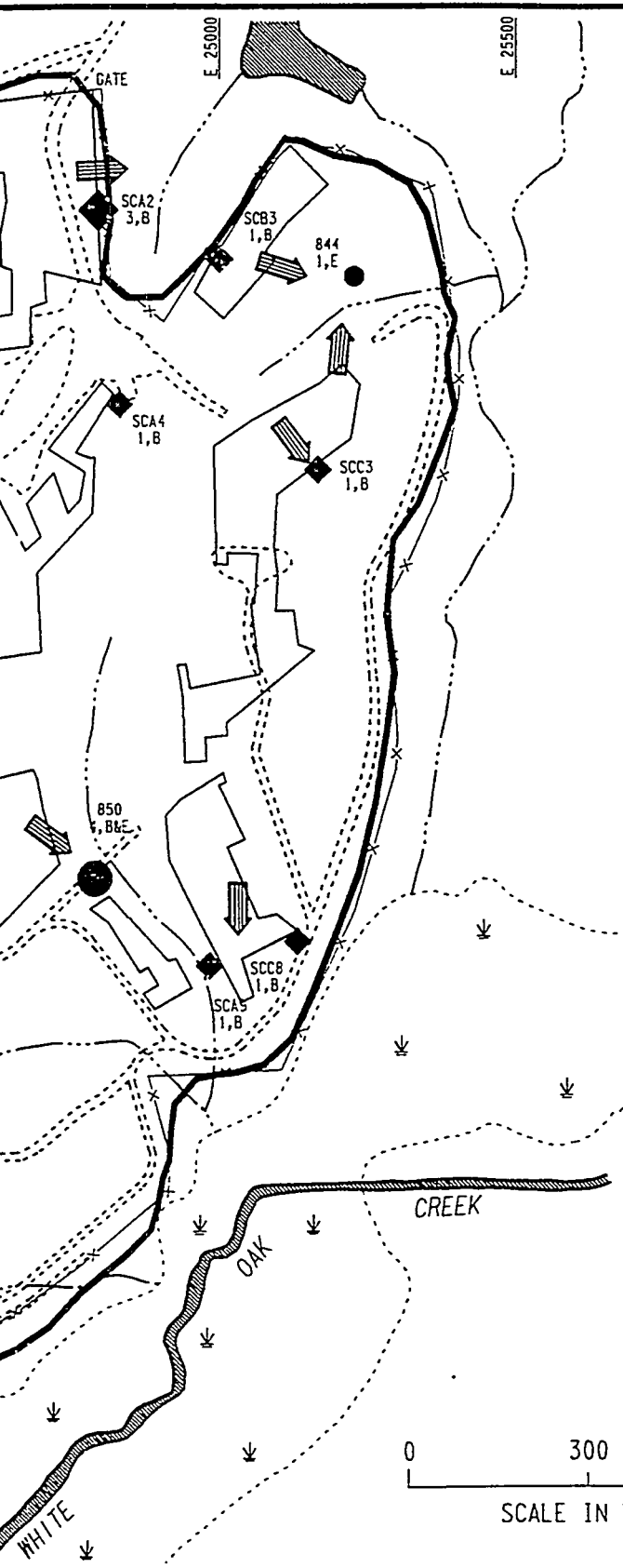
B =	RFI SAMPLING
C =	SOLOMON, et al (1988)
E =	ORNL REGULATORY COMPLIANCE MONITORING RESULTS

LEGEND

- | | |
|--|--|
| | WAG 6 BOUNDARY |
| | TRIBUTARY |
| | SWSA SECURITY FENCE |
| | GRAVEL ROAD |
| | WASTE AREA |
| | POTENTIAL CONTAMINANT MIGRATION |
| | SAMPLE DESIGNATION |
| | RANGE OF CONCENTRATION, SOURCE OF DATA |
| | GROUNDWATER SAMPLE |
| | TRENCH LEACHATE SAMPLE |
| | SOIL BORING |

FIGURE 5-20
DISTRIBUTION OF ETHYL
BENZENE





NOTES

1. ALL SURFACE WATER, GROUNDWATER, AND LEACHATE CONCENTRATIONS IN UG/L.
2. ALL SOIL CONCENTRATIONS IN UG/KG.
3. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
4. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
5. THE RANGES OF CONCENTRATION INDICATED ARE AS FOLLOWS:

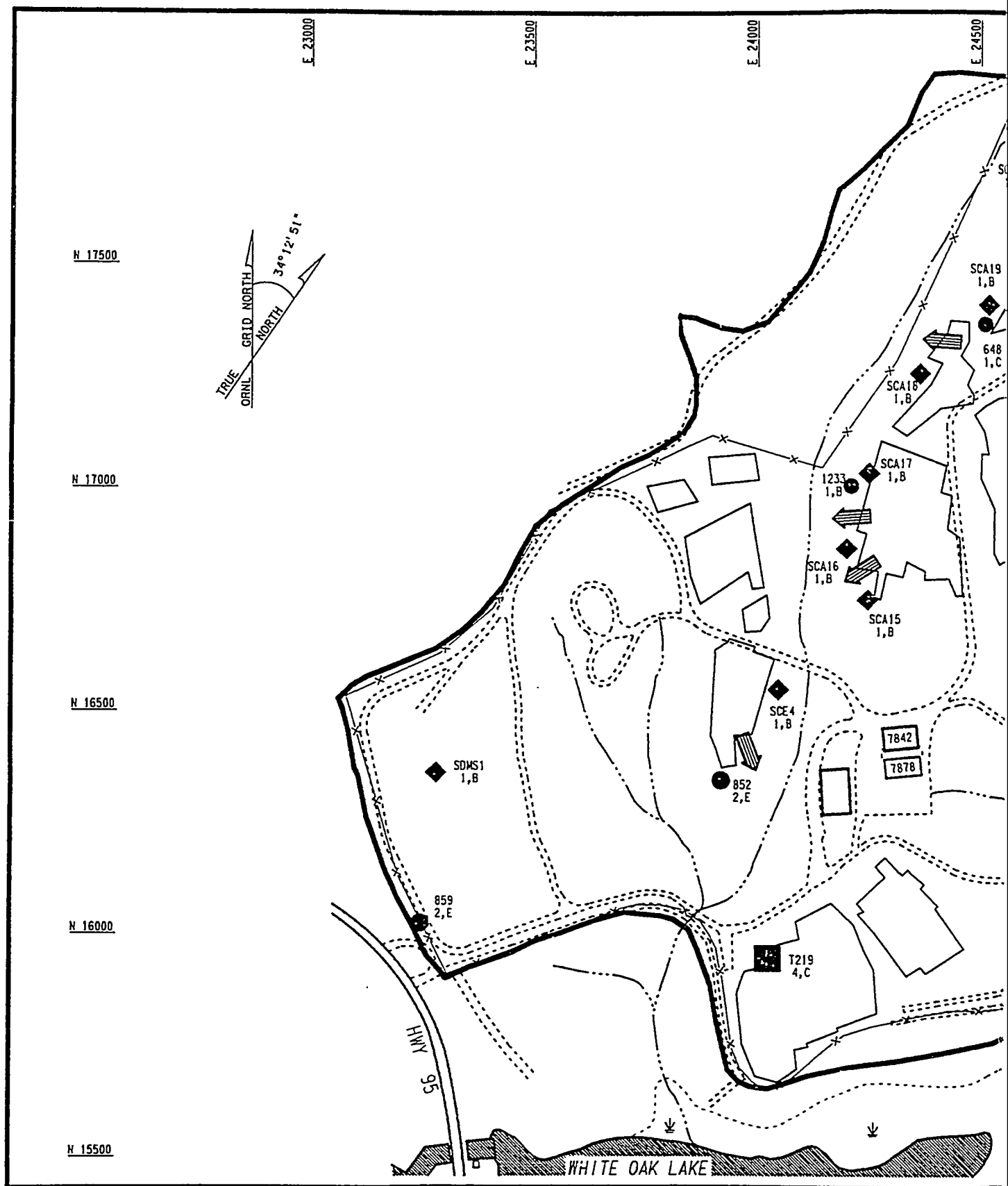
1 =	1 - 9.99
2 =	10 - 99.9
3 =	100 - 999
4 =	1000 - 9,999
5 =	10,000 - 99,999
6. THE SOURCES OF DATA ARE AS FOLLOWS:

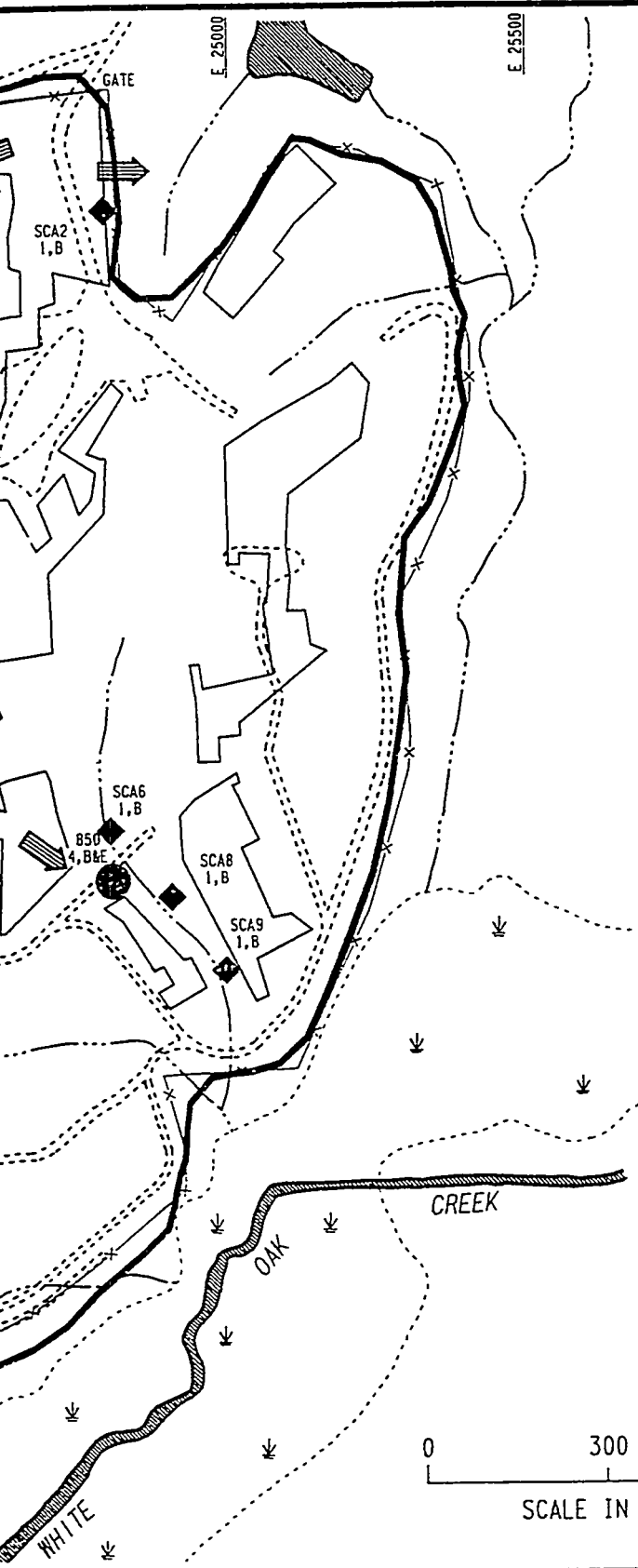
B =	RFI SAMPLING
C =	SOLOMON, et al (1988)
E =	ORNL REGULATORY COMPLIANCE MONITORING RESULTS

LEGEND

- | | |
|--|--|
| | WAG 6 BOUNDARY |
| | TRIBUTARY |
| | SWSA SECURITY FENCE |
| | GRAVEL ROAD |
| | WASTE AREA |
| | POTENTIAL CONTAMINANT MIGRATION |
| | SAMPLE DESIGNATION
RANGE OF CONCENTRATION, SOURCE OF DATA |
| | GROUNDWATER SAMPLE |
| | TRENCH LEACHATE SAMPLE |
| | SURFACE WATER SAMPLE |
| | SOIL BORING |

FIGURE 5-21
DISTRIBUTION OF TOLUENE
5-59





NOTES

1. ALL SURFACE WATER, GROUNDWATER, AND LEACHATE CONCENTRATIONS IN UG/L.
2. ALL SOIL CONCENTRATIONS IN UG/KG.
3. SAMPLE SYMBOLS PROVIDE ONLY APPROXIMATE SAMPLE LOCATIONS.
4. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
5. THE RANGES OF CONCENTRATION INDICATED ARE AS FOLLOWS:

1 =	1 - 9.99
2 =	10 - 99.9
3 =	100 - 999
4 =	1000 - 9,999
5 =	10,000 - 99,999
6. THE SOURCES OF DATA ARE AS FOLLOWS:
 - B = RFI SAMPLING
 - C = SOLOMON, et al (1988)
 - E = ORNL REGULATORY COMPLIANCE MONITORING RESULTS

LEGEND

- WAG 6 BOUNDARY
- - - - - TRIBUTARY
- x - SWSA SECURITY FENCE
- - - - - GRAVEL ROAD
- ▭ WASTE AREA
- ← POTENTIAL CONTAMINANT MIGRATION
- T135 — SAMPLE DESIGNATION
- 3,C — RANGE OF CONCENTRATION, SOURCE OF DATA
- GROUNDWATER SAMPLE
- ▣ TRENCH LEACHATE SAMPLE
- SURFACE WATER SAMPLE
- ◆ SOIL BORING

FIGURE 5-22
DISTRIBUTION OF XYLENE

49-trench area, 2) the 49-trench area, 3) the biological trench group to the southeast of the 49-trench area, 4) the biological trench group in the west disposal area, and 5) the biological trench group in the south disposal area. As indicated on Figure 5-19, groundwater samples with levels exceeding the SDWA MCL are associated with all but the latter area (the biological trench group in the south disposal area). In this area, benzene was detected at 929 ppb in leachate from trench 219, but in only one environmental sample around the perimeter of the trench group (3 ppb in Well 835).

Ethyl benzene. Ethyl benzene was detected at two trench leachate sampling locations, one groundwater sampling location, and eight soil sampling locations (Figure 5-20). The levels in water exceeded the drinking water health advisory of 700 ppb at one trench leachate location and one groundwater sampling location. The levels detected in soil are many orders of magnitude less than the human health criteria for soil derived in Section 7.0 (8,000,000 ppb).

The data indicate at least four trench groups as sources of ethyl benzene release: 1) the high-activity trench area at the north end of the central disposal area, 2) the biological trench group to the southeast of the 49-trench area, 3) the west disposal area, and 4) the south disposal area. However, the only environmental sample (i.e., not a trench leachate sample) location with a significant level of ethyl benzene was Well 850 (700 ppb), which is downgradient of the biological trench area located to the southeast of the 49-trench area. This is the same well in which toluene and total xylenes were detected at levels exceeding human health criteria developed in Section 7.0.

The trench leachate sample that approached the drinking water health advisory was from trench 288, located in the biological trench group in the west disposal area. The concentration measured in this trench was 720 ppb (Solomon et al., 1988). Ethyl benzene was detected in four soil samples from borings

around the perimeter of the west disposal area; however, all concentrations were less than 5 ppb (i.e., extremely low compared to the health advisory).

Toluene. Toluene was detected at one trench leachate sampling location, four groundwater sampling locations, two surface water sampling locations, and nine soil sampling locations (Figure 5-21). The levels in water approached the drinking water health advisory of 2,000 ppb at one trench leachate location and one groundwater sampling location. The levels detected in soil are many orders of magnitude less than the human health criteria for soil derived in Section 7.0 (29,000,000 ppb).

As indicated on Figure 5-21, the data indicate numerous potential sources of toluene across the site. However, the only environmental sample (i.e., non-trench leachate sample) location with a significant level of toluene was Well 850 (1,900 ppb), which is downgradient of the biological trench area located to the southeast of the 49-trench area. This is the same well in which ethyl benzene and xylene exceeded human health criteria developed in Section 7.0.

The trench leachate sample that approached the drinking water health advisory was from trench 288, located in the biological trench group in the west disposal area. The concentration measured in this trench was 1,940 ppb (Solomon et al., 1988). The only environmental sample around the perimeter of this area in which toluene was detected was soil sample SCE4 (4 ppb).

Total Xylenes. Xylenes were detected at 1 trench leachate sampling location, 5 groundwater sampling locations, and 12 soil sampling locations (Figure 5-22). The levels in water exceeded the drinking water health advisory of 100 ppb at one trench leachate location and one groundwater sampling location. The

levels detected in soil are many orders of magnitude less than the human health criteria for soil derived in Section 7.0 (160,000,000 ppb).

As indicated on Figure 5-22, the data indicate numerous trench and auger hole groups as source areas of xylenes, most of which are located within the central waste disposal area. However, the only environmental sample (i.e., non-trench leachate sample) location with a significant level of xylenes was Well 850 (3,800 ppb), which is downgradient of the biological trench area located to the southeast of the 49-trench area. This is the same well in which toluene and total xylenes were detected at levels exceeding human health criteria developed in Section 7.0.

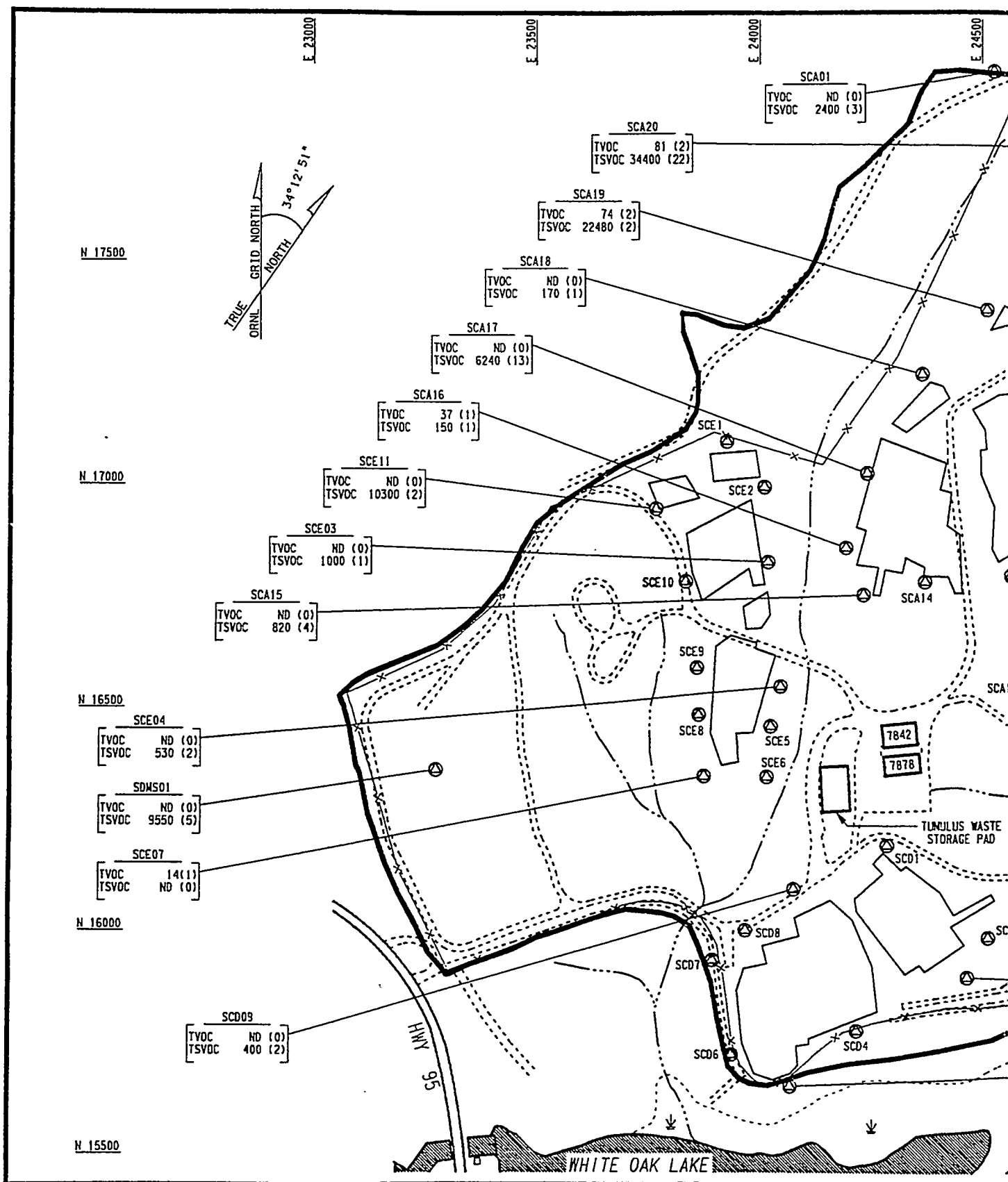
The trench leachate sample that exceeded the drinking water health advisory was taken from trench 219, located in the biological trench group in the south disposal area. The concentration measured in this trench was 3,696 ppb (Solomon et al., 1988). Xylenes were not detected in any environmental samples collected from around the perimeter of the area.

Ketones

Four ketones were detected during environmental sampling at WAG 6: 2-propanone (acetone), 2-hexanone, 2-butanone (methyl ethyl ketone or MEK), and 4-methyl-2-pentanone. Tables 5-7 through 5-12 list the ranges at which ketones were detected. None were detected at levels exceeding the human health criteria developed in Section 7.0. The maximum levels detected at each location are described in Appendix B.

VOC Tentatively Identified Compounds (TICs)

Approximately 15 VOC TICs were detected during the WAG 6 soil sampling program. Figure 5-23 shows the number found in each boring and includes an indication of the levels encountered. The



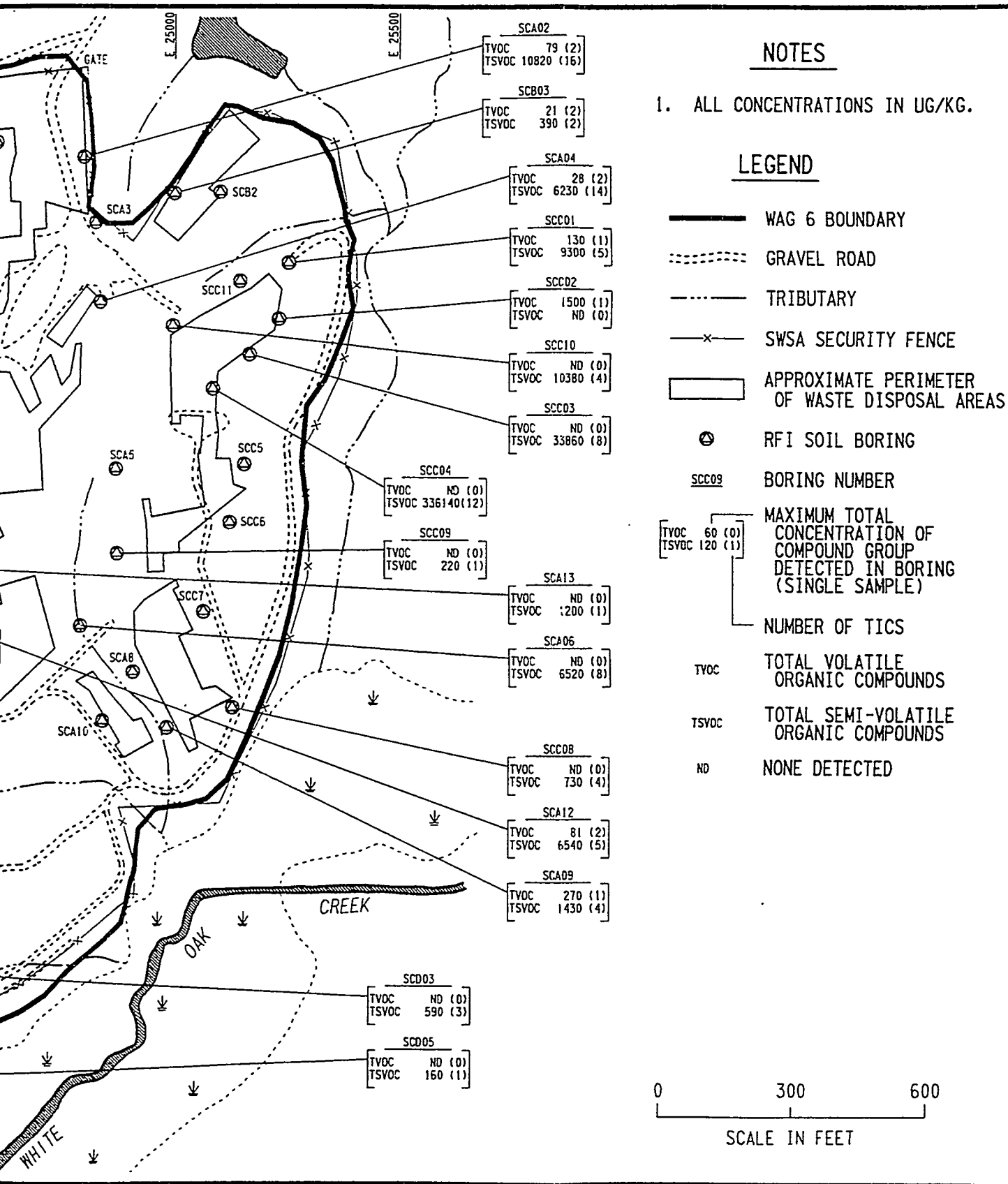


FIGURE 5-23
TENTATIVELY IDENTIFIED ORGANIC
COMPOUNDS IN SOILS

number of VOC TICs was 0 in 26 boreholes, 1 in 5 boreholes, and 2 in 6 boreholes. The maximum total TIC VOC concentration was 1,500 ppb.

5.2.2.2 Semivolatile Organic Compounds (SVOCs). Approximately 20 SVOCs have been detected during environmental sampling at WAG 6. These compounds are grouped below as phthalates (four detected), phenols (five detected), polyaromatic hydrocarbons (five detected), and "other compounds" (four detected). Tables 5-7 through 5-12 list these compounds and the ranges at which they were detected.

Of the eight SVOCs for which human health criteria were developed in Section 7.0, only one was detected at a level exceeding human health criteria. Bis(2-ethylhexyl)phthalate was detected in groundwater at levels exceeding human health criteria.

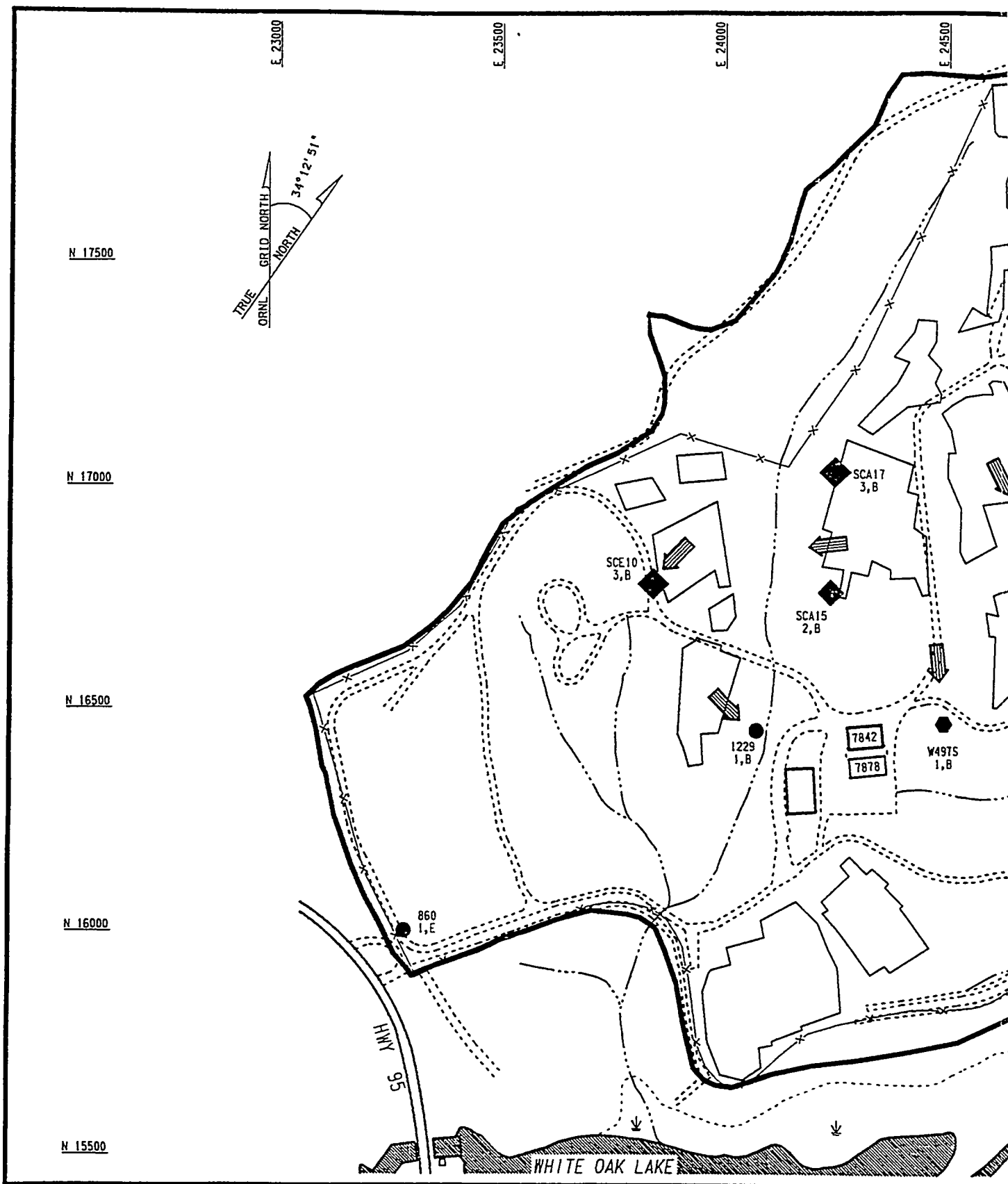
In the following subsections, phthalates, phenols, polyaromatics, and other SVOC compounds detected at WAG 6 are briefly discussed.

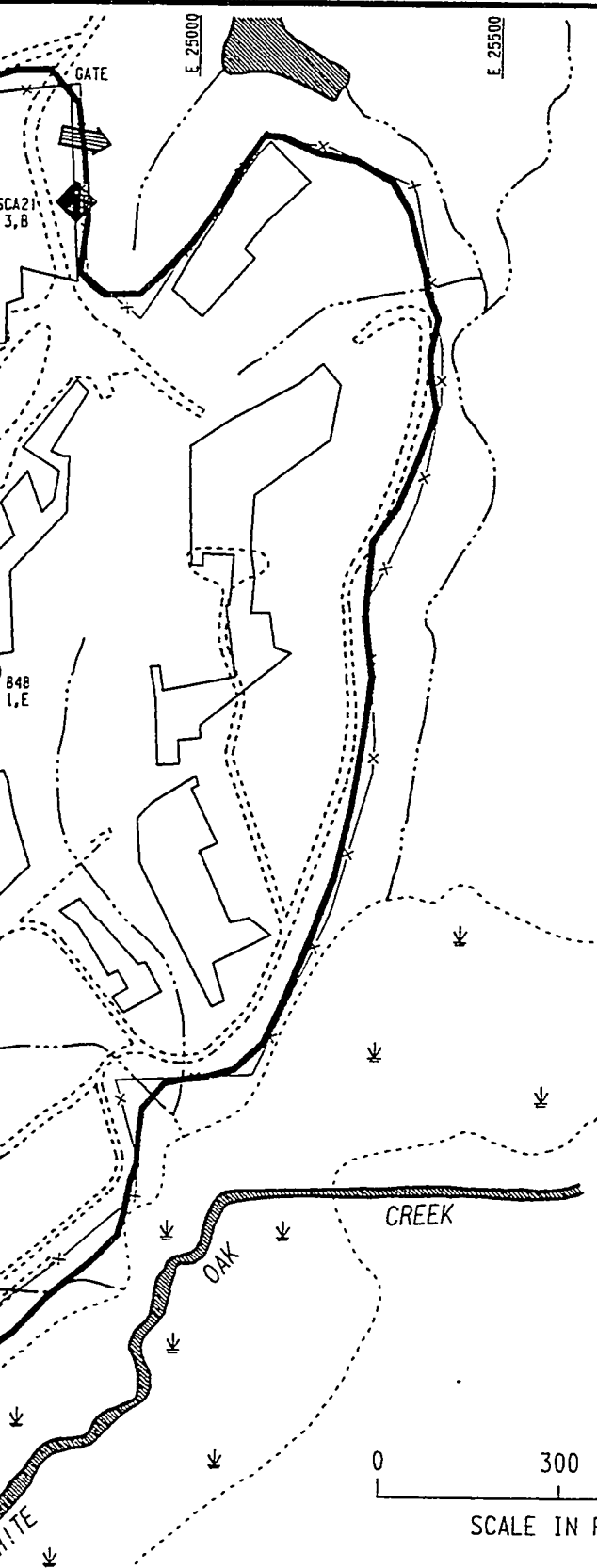
Phthalates

The pathalate compounds detected were bis(2-ethylhexyl)phthalate, diethyl phthalate, di-n-butyl phthalate, and di-n-octyl phthalate.

Bis(2-ethylhexyl)phthalate was the only phthalate (and SVOC) detected above human health criteria identified in Section 7.0. It was also the most common phthalate detected, accounting for 11 of the 19 phthalate detects. Figure 5-24 illustrates the distribution of bis(2-ethylhexyl)phthalate at WAG 6.

Of the 11 locations at which bis(2-ethylhexyl)phthalate was detected, 3 were groundwater sampling locations, 2 were surface water sampling locations, and 6 were soil sampling locations.





NOTES

1. ALL SURFACE WATER, GROUNDWATER, AND LEACHATE CONCENTRATIONS IN MG/L.
2. ALL SOIL CONCENTRATIONS IN UG/KG.
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4. THE RELATIVE SIZES OF THE SAMPLE SYMBOLS PROVIDE A MEASURE OF THE RELATIVE CONCENTRATION OF THE ANALYTE.
5. THE RANGES OF CONCENTRATION INDICATED ARE AS FOLLOWS:

1 =	1 - 9.99
2 =	10 - 99.9
3 =	100 - 999
4 =	1000 - 9,999
5 =	10,000 - 99,999
6. THE SOURCES OF DATA ARE AS FOLLOWS:

B =	RFI SAMPLING
E =	ORNL REGULATORY COMPLIANCE MONITORING RESULTS

LEGEND

- WAG 6 BOUNDARY
- TRIBUTARY
- x SWSA SECURITY FENCE
- GRAVEL ROAD
- WASTE AREA
- POTENTIAL CONTAMINANT MIGRATION
- T135 — SAMPLE DESIGNATION
- 3,C — RANGE OF CONCENTRATION, SOURCE OF DATA
- GROUNDWATER SAMPLE
- SURFACE WATER SAMPLE
- SOIL BORING

FIGURE 5-24
DISTRIBUTION OF
BIS (2-ETHYLHEXYL) PHTHALATE
5-66

The maximum value at each of the groundwater and surface water sampling locations (where the compound was detected) approach or exceed 2.5 ppb, which is the human health criteria developed for drinking water in Section 7.0. The concentrations detected in soil are approximately two orders of magnitude less than the human health standard developed for soil (50,000 ppb).

Bis(2-ethylhexyl) phthalate is a plasticizer for polyvinyl chloride and other plastics, and it is possible that it has been disposed in SWSA 6. The compound was detected primarily around the perimeter of the central disposal area and the west disposal area. The locations at which the levels detected approach or exceed the drinking water criteria developed in Section 7.0 are associated with: 1) the high-activity trenches at the north end of the central disposal area, 2) the low-activity trench group just to the east of the 49-trench group, and 3) the biological trench group in the west disposal area.

Phenols

A total of five different phenols were detected during Phase 1, Activity 1 RFI sampling and sampling conducted by Solomon et al. (1988). They include phenol, 2-methyl phenol, 4-methyl phenol, 2,4-dimethyl phenol, and N-nitrosodiphenylamine. Tables 5-7 through 5-12 list the ranges at which they were detected.

Trench leachate sampling by Solomon et al. (1988) showed phenols in three trench areas. In the 49-trench area, leachate from trench 163 contained phenol at 12 ppb and 4-methyl phenol at 91 ppb. However, phenols were not detected in soil and groundwater samples collected from locations downgradient of the trench or from the outfall of the 49-trench drain.

At the southern edge of the west disposal area, leachate collected from trench 288 showed phenol at 13 ppb, 2,4-dimethyl phenol at 32 ppb, 4-methyl phenol at 141 ppb, and 2-methyl phenol

at 26 ppb. No phenols were detected in soil or groundwater samples collected downgradient of this trench.

At trench 219, located in the biological trench area in the south disposal area, 4-methylphenol was detected at 34 ppb. No phenols were detected in soil or groundwater samples collected downgradient.

The only environmental samples in which phenols were detected came from soil borings located in the northeastern area of the site. Phenol was detected in SCB3 at 93 ppb in the 17-trench area (an area of high-activity trenches), and N-nitrosodiphenylamine was detected in SCC2 at 61 ppb. SCC2 is located in the vicinity of solvent auger holes.

In summary, it appears that several phenolic compounds have been disposed at SWSA 6, but these are not apparently migrating at high concentrations from the disposal trenches and auger holes.

Polynuclear Aromatic Hydrocarbons (PAH) Compounds

Six PAH compounds were detected at WAG 6; however, they do not appear to be widely distributed. Of the six compounds, three were found only at one location [benzo(a)anthracene, benzo(b)-fluoranthene, and benzo(k)fluoranthene], two were found at two locations [benzo(a)pyrene and chrysene], and naphthalene was found in eight locations. With the exception of naphthalene, the PAH compounds listed above were found only in soils. Tables 5-7 through 5-12 list the ranges at which they were detected. None of the PAH compounds detected exceeded human health criteria. The distributions of these compounds is described in Appendix B.

Other SVOCs

Other SVOCs detected include benzoic acid and benzyl alcohol. Benzoic acid was detected at only one location during the

Phase 1, Activity 1 RFI. It was detected in soil at 67 ppb. This value is much less than the soil human health criteria of 320,000,000 ppb developed in Section 7.0. Benzyl alcohol was detected in five samples collected from three boreholes; the concentrations detected ranged from 260 to 350 ppb. No soil human health criteria is available for benzyl alcohol. The distributions of both benzoic acid and benzyl alcohol are discussed in Appendix B.

SVOC Tentatively Identified Compounds (TICs)

Approximately 50 SVOC TICs were detected during the WAG 6 soil sampling program (excluding unknowns). Figure 5-23 shows the number found in each boring and includes an indication of the levels encountered. The greatest number of SVOC TICs encountered were 16 in SCA2, 14 in SCA4, 13 in SCA17, 22 in SCA20, and 12 in SCC4. The number of SVOC TICs encountered in the remaining boreholes generally numbered less than five. The number of TICs reported for individual borings is listed here as a general indication of where significant quantities of diverse chemicals may have been disposed.

5.2.3 Polychlorinated Biphenyls (PCBs)

PCB-1254 was detected at two locations at WAG 6. It was detected at a level of 0.6 ppb in Well 836, located on the southern perimeter of the south biological trench area, and at 1 ppb in Well 854, located on the western perimeter of the west disposal area. For comparison, the human health criteria for drinking water identified in Section 7.0 is 1 ppb. PCB-1254 was detected in only one sample from each location, both collected during the first quarter of 1989. It was not present in samples collected during the previous two quarters. In summary, the data indicate that PCB-1254 is present at relatively low levels and only in very limited areas of the site.

5.2.4 Inorganic Chemical Contamination

5.2.4.1 Soils. Table 5-14 provides a comparison of RFI Phase 1, Activity 1 soil data for 24 inorganic constituents with typical values reported in the literature. Tables 5-9, 10, and 12 provide comparison of RFI Phase 1, Activity 1 values with human health criteria developed in Section 7.0. The comparison with typical background values indicates that the concentrations measured in WAG 6 soils are generally within ranges found in natural soils. Only arsenic detected in a subsurface soil sample collected from soil boring SCA18 (1.95 mg/Kg) exceeded the human health criteria developed in Section 7.0. Site specific background sample results are forthcoming and will be incorporated in the RFI report discussion.

Of interest are a few of the less frequently detected inorganic constituents. Mercury was detected in nine boreholes. Seven of these are in the north and northeast areas of the site. However, the highest concentration (0.7 mg/kg) was detected at the Hillside Box experiment site. Cyanides were detected in only three boreholes, all in the northern half of the site. Thallium was detected in one sample, at the extreme southern end of the site. Final analysis to determine if WAG 6 contains elevated concentrations of some inorganic constituents must await the development of site-specific background data.

5.2.4.2 Groundwater and Surface Water. Tables 5-7 and 5-8 provide a comparison of RFI Phase 1, Activity 1 groundwater and surface water inorganics data, respectively, with human health criteria identified developed in Section 7.0. The human health criteria listed in the tables were exceeded at approximately 12 groundwater and 3 surface water sampling locations. An analysis to determine if WAG 6 contains elevated concentrations relative to natural background must await development of site-specific background data. This analysis will be presented in the WAG 6 RFI report.

TABLE 5-14

COMPARISON OF INORGANIC CONSTITUENTS IN SOIL
WITH TYPICAL BACKGROUND LEVELS

Constituent	Site Concentrations (mg/kg) ^(a)			Typical Range of Concentrations in Soils	
	Average ^(b)	Minimum	Maximum ^(c)	Concentration (mg/kg)	Reference ^(d)
Aluminum	20,000	11,900	31,700	10,000 - 300,000	1
Antimony	0.7	<0.01 J	1.2 J	0.2 - 150	1,2,3,4
Arsenic	15	<1 J	195	0.1 - 194	5
Barium	227	68.6	420	100 - 3,000	1
Beryllium	1.4	<0.9 J	2	0.01 - 40	1
Cadmium	2.5	<0.5	6.1	0.01 - 7	6
Calcium	5,660	290 J	54,700	<150 - 500,000	1,7
Chromium	37	24 J	52.3	5 - 3,000	6
Cobalt	23	11 J	120 J	0.05 - 65	1
Copper	25	6 J	86.7 J	2 - 250	1
Cyanides	0.7	<0.06	3.2		
Iron	33,800	21,300	44,500	100 - 550,000	1,5
Lead	16	3.2	243 J	<1 - 888	5
Magnesium	7,340	65	45,700	400 - 9,000	1
Manganese	1,140	282	7,230 J	20 - 18,300	1,5,6
Mercury	0.1	<0.02	0.7 J	<0.01 - 4.6	5
Nickel	49	24	86.6 J	0.1 - 1,530	1,5
Potassium	2,280	399	4,570 J	80 - 37,000	1
Selenium	0.3	<0.3	0.9 J	0.1 - 38	1,6
Silver	0.2	<0.1	0.6 J	0.01 - 8	5
Sodium	90	<40 J	194 J	150 - 25,000	1
Thallium	0.2	<0.2 J	1	0.1 - 0.8	1
Vanadium	19	8.5 J	34 J	3 - 500	1,6,7
Zinc	72	37.7	143 J	1 - 2,000	1,5

(a) Data qualifier: J = estimated value.

(b) Average computed assuming non-detect values of one half the detection limit.

(c) Maximum computed as the maximum value for detected constituents.

(d) References:

- (1) Bowen, H. J. M. Environmental Chemistry of the Elements. Academic Press, New York, 1979.
- (2) Ragaini, R. C., et al. "Environmental Trace Contamination in Kellogg, Idaho Near Lead Smelting Complex." Environmental Science and Technology, Volume 11, pp 773-780. 1977.
- (3) Lisk, D. J. "Trace Metals in Soils, Plants, and Animals." Adv. Agron., Volume 24, pp 267-311. 1972.
- (4) Conner, et al. Geochemistry of Some Rocks, Soils, Plants, and Vegetables in the Conterminous United States. Geological Survey Professional Paper 575 F. 1975.
- (5) Ure, A. M., et al. "Elemental Constituents of Soils." Environmental Chemistry, Volume 2, pp 94-204.
- (6) Parr, J. F., P. B. Marsh, and J. M. Kla. Land Treatment of Hazardous Wastes. Agricultural Environmental Quality Data Institute, Agricultural Research Service, USDA, Beltsville, MD, Noyes Data Corporation, Park Ridge, NJ. 1983.
- (7) Shaklette, H. T., et al. Elemental Composition of Surficial Material in the Conterminous United States. USGS Professional Paper 574-D. 1971.

5.3 BIOLOGICAL CONTAMINATION

The largest single source of waste materials in SWSA-6 was the ORNL Biology Division (BNI, 1988). These biological waste disposal trenches received wastes consisting of animal remains, bedding, pathology specimens, microbiological wastes, and expended biological reagents. In view of the types of research that have been conducted at the Biology Division over the period of active burial, a health and safety survey for the presence of microbiological hazards was conducted. The following paragraphs summarize the investigation and its results.

5.3.1 Background

Most bacteria are considered to be "opportunistic pathogens" (i.e., if large numbers are introduced into the body, disease can result). In the course of biological research, many bacteria are used as tools or as test subjects in the laboratory. Research into the function of the immune system (such as that conducted at the Biology Division) often includes the intentional exposure of test animals to disease-producing bacteria and viruses.

The burial of animal remains, bedding, excreta, and expended microbiological media would also create a rich food source in the area of the disposal trenches for naturally occurring bacteria in the soil. This food source would result in an increase in the numbers of these naturally occurring bacteria near each biological trench group. Additionally, but at an extremely low probability of occurrence, the presence of mutagenic agents (chemicals and/or radiation that cause genetic mutations) in the wastes could result in the expression of new characteristics in the soil bacteria (Davis, 1988a; Davis, 1988b).

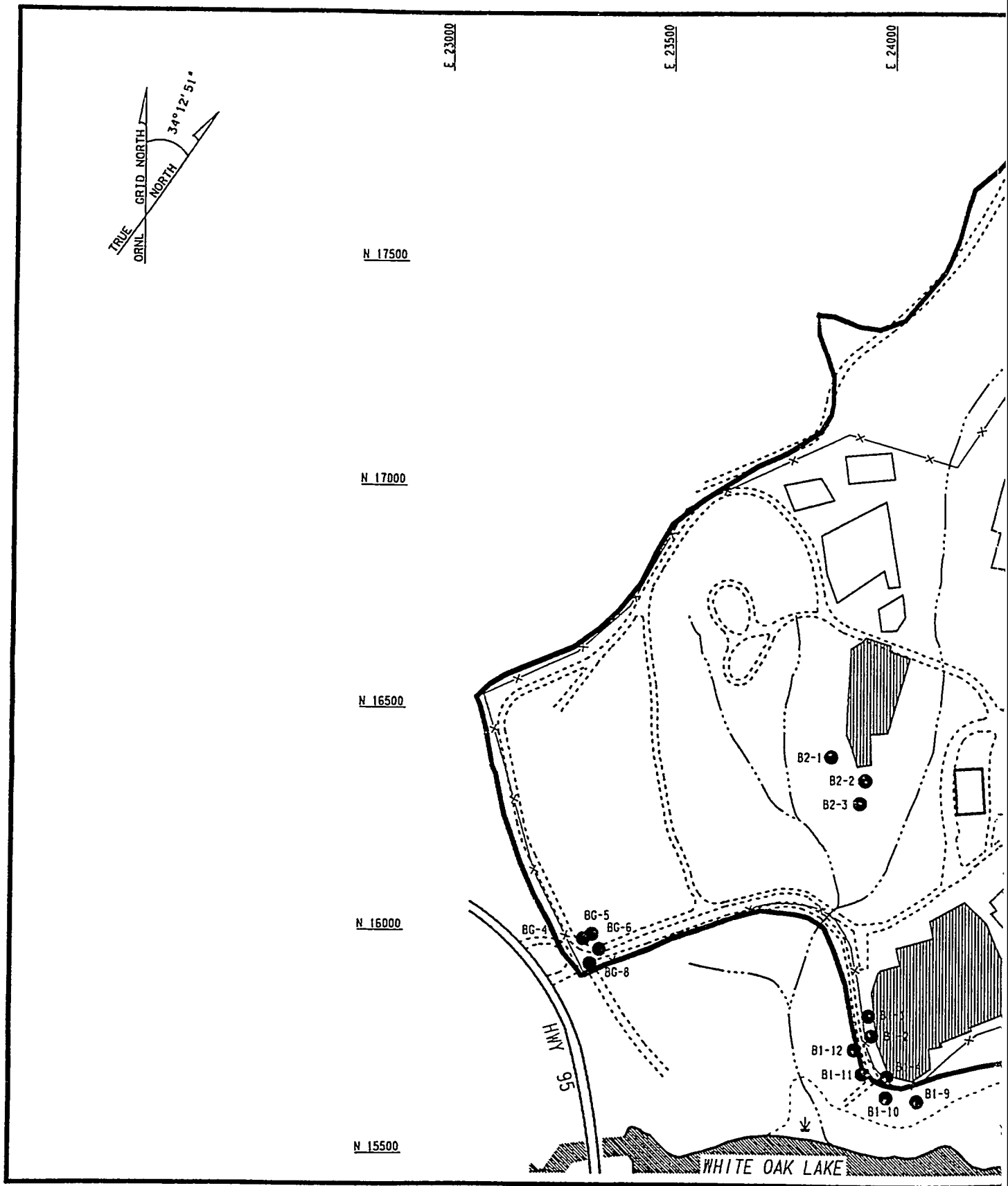
5.3.2 Phase I Investigation

Beginning in August 1988, soil samples were collected from 16 locations. The samples were divided into two groups: one group consisting of samples collected from locations downslope of biological trench areas and the other group consisting of samples collected from an undisturbed area of SWSA 6. The samples were tested for total numbers of bacteria and fungi per gram of soil. Additionally, bacteria and fungi were identified by the appearance of the colonies and by microscopic examination.

Groundwater samples were collected from Wells 833, 835, 836, 852, 854, 860, 858, 856, and 837 (see Figure 5-25). These samples were tested for total bacteria and fungi per milliliter. As with the soils, the bacteria and fungi present were identified by the appearance of the colonies and by microscopic examination.

Soil and groundwater results are presented in Tables 5-15 and 5-16, respectively. The numbers of bacteria and fungi found in soil were considered to be within the normal range with no significant difference between the background area and the areas downslope from the biological trenches. The types of bacteria and fungi found were also normal (Pelczar and Reid, 1972).

In groundwater, the numbers of bacteria and fungi were higher than expected in clean, natural waters (Pelczar and Reid, 1972). Higher numbers were associated with the southwestern area of the site. A sample from Well 858 indicated the presence of a member of the bacteria group known as the Pasteurella. The Pasteurella are a group of bacteria that contain several animal pathogens of different degrees of infectivity as well as relatively harmless strains. Pasteurella are not considered a bacteria normally encountered in clean groundwater.



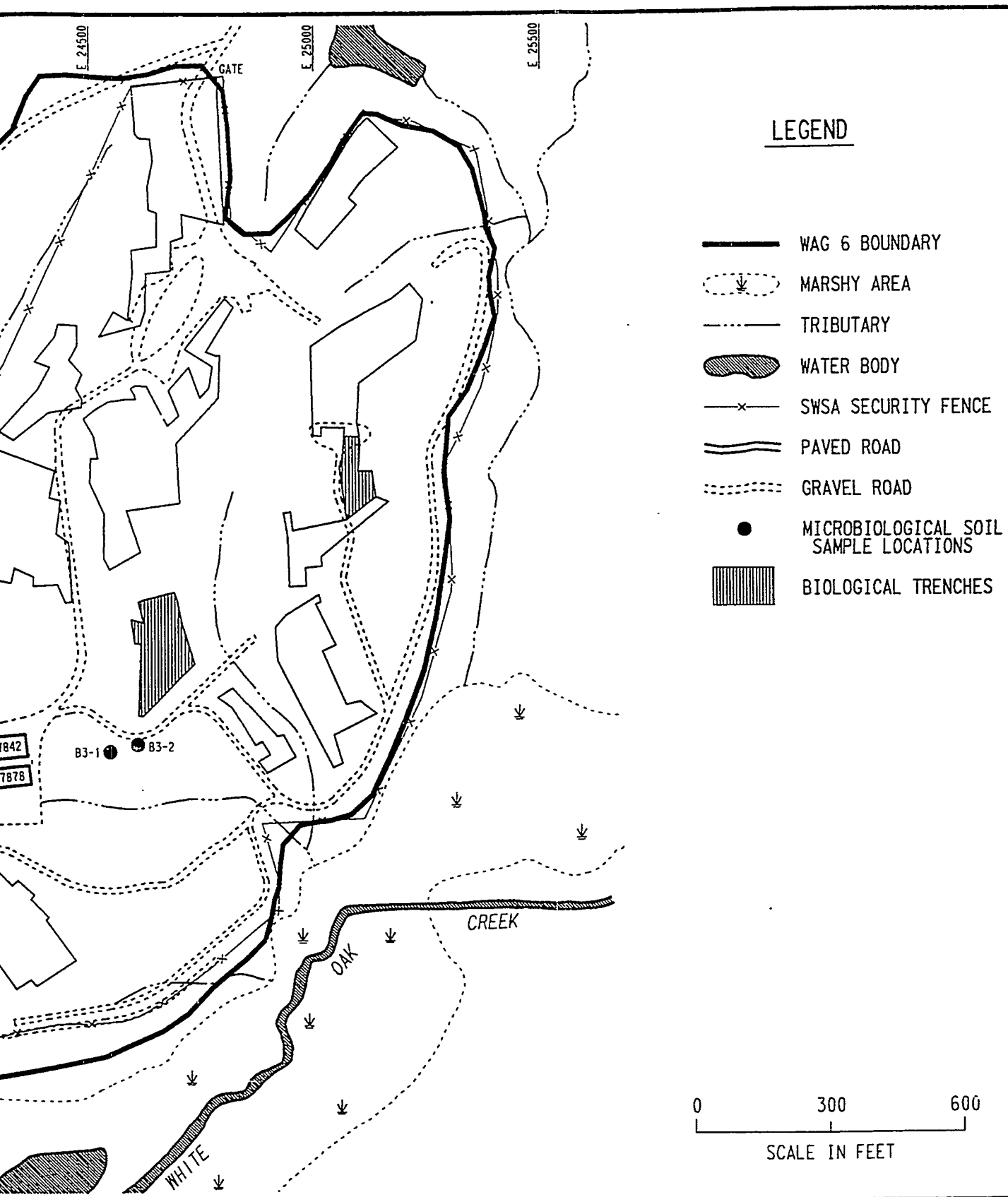


FIGURE 5-25
SOIL MICROBIOLOGICAL SAMPLE
LOCATIONS PHASE 1

TABLE 5-15

SWSA 6 SOIL MICROBIOLOGICAL DATA, PHASE 1

Sample	Bacteria CFU/g	Fungi CFU/g	Total CFU/g	Comment
B1-1	1.e+05	1.e+04	1.e+05	Bacillus, Pseudomonas, Micrococcus, Mucor, Aspergillus, Penicillium
B1-2	1.e+05	1.e+04	1.e+05	Bacillus, Actinomycetes, Candida, Penicillium, Mucor, Fusarium
B1-4	1.e+05	1.e+04	1.e+05	Bacillus, Micrococcus, Penicillium
B1-9	1.e+05	1.e+04	1.e+05	Bacillus, Penicillium
B1-10	1.e+06	1.e+04	1.e+06	Bacillus, Candida, Flavobacter, Penicillium, Aspergillus
B1-11	1.e+06	1.e+04	1.e+06	Bacillus, Actinomycetes, Micrococcus, Rhodospirillum, Aspergillus, Penicillium
B1-12	1.e+06	1.e+04	1.e+06	Bacillus, Micrococcus, Aspergillus, Penicillium, Mucor, Rhizopium
Average	6.e+05	1.e+04	6.e+05	
B2-1	1.e+05	1.e+04	1.e+05	Bacillus, Pseudomonas, Micrococcus, Fusarium, Mucor, Penicillium, Aspergillus
B2-2	1.e+05	1.e+04	1.e+05	Bacillus, Actinomycetes, Micrococcus, Rhodospirillum, Aspergillus, Penicillium
B2-3	1.e+05	1.e+04	1.e+05	Bacillus, Actinomycetes, Micrococcus, Rhodospirillum, Aspergillus, Penicillium
B3-1	1.e+05	1.e+04	1.e+05	Pseudomonas, Actinomycetes, Penicillium, Aspergillus, Fusarium
B3-2	1.e+05	1.e+04	1.e+05	Bacillus, Pseudomonas, Actinomycetes, Penicillium, Aspergillus
Average	1.e+05	1.e+04	1.e+05	
BG-4	1.e+05	1.e+04	1.e+05	Bacillus, Flavobacter, Micrococcus, Penicillium, Aspergillus
BG-5	1.e+05	1.e+05	2.e+05	Bacillus, Actinomycetes, Mucor, Penicillium, Aspergillus, Rhizopus
BG-6	1.e+05	1.e+04	1.e+05	Pseudomonas, Flavobacter, Bacillus, Actinomycetes, Penicillium
BG-8	1.e+05	1.e+04	1.e+05	Bacillus, Bacillus, Penicillium, Aspergillus
Average	1.e+05	3.e+04	1.e+05	

TABLE 5-16

SWSA 6 GROUNDWATER MICROBIOLOGICAL RESULTS, PHASE 1

Well	Cap Area	Bacteria CFU/mL	Fungi CFU/mL	Comment
W833	8	1.e+04	1.e+04	Gram Negative Rods
W835	8	1.e+04	<1.e+03	
W836	8	1.e+04	<1.e+03	
W850	2	<1.e+04	<1.e+03	
W851	2	1.e+04	<1.e+03	Pseudomonas Flavobacter
W852	4	1.e+04	<1.e+03	
W854	SW Area	1.e+03	<1.e+04	
W856	SW Area	1.e+05	<1.e+03	Gram Negative Rods
W858	SW Area	1.e+06	<1.e+03	
W860	SW Area	1.e+03	<1.e+03	

5.3.3 Phase II

Based on the detection of Pasteurella in the first sampling, a more extensive sampling of the groundwater at SWSA 6 was conducted in November and December 1988. Phase II analyses were designed to concentrate on the Pasteurella bacteria and to evaluate the groundwater for common pathogens often associated with polluted waters. Table 5-17 and Figure 5-26 indicate where samples were taken in this phase of the investigation.

Phase II results are shown in Table 5-18. These results show that total numbers of bacteria were reduced from that found in August 1988. This decrease was attributed to seasonal effects. As in Phase I, the Pasteurella-like organism was recovered from Well 858. In Phase II, this organism was also recovered from Wells 856, 840, and 850, indicating a larger distribution of this bacteria than was initially discovered in Phase I.

To identify the particular Pasteurella that was involved, samples were submitted to two microbiological laboratories; neither laboratory was able to identify the bacterium.

To evaluate the potential hazard of the organism, suspensions of the bacteria were injected into the body cavities of 6- to 8-week-old mice. Over the course of this experiment, no mice died of acute disease. However, of the mice injected, all yielded live bacteria from the tissues of the lungs. Control animals were free of live bacteria in the lung tissues. Autopsy of the test mice indicated that there had been bacterial invasion of the lung tissue.

Results of cultures for other waterborne pathogens were either negative or inconclusive.

TABLE 5-17

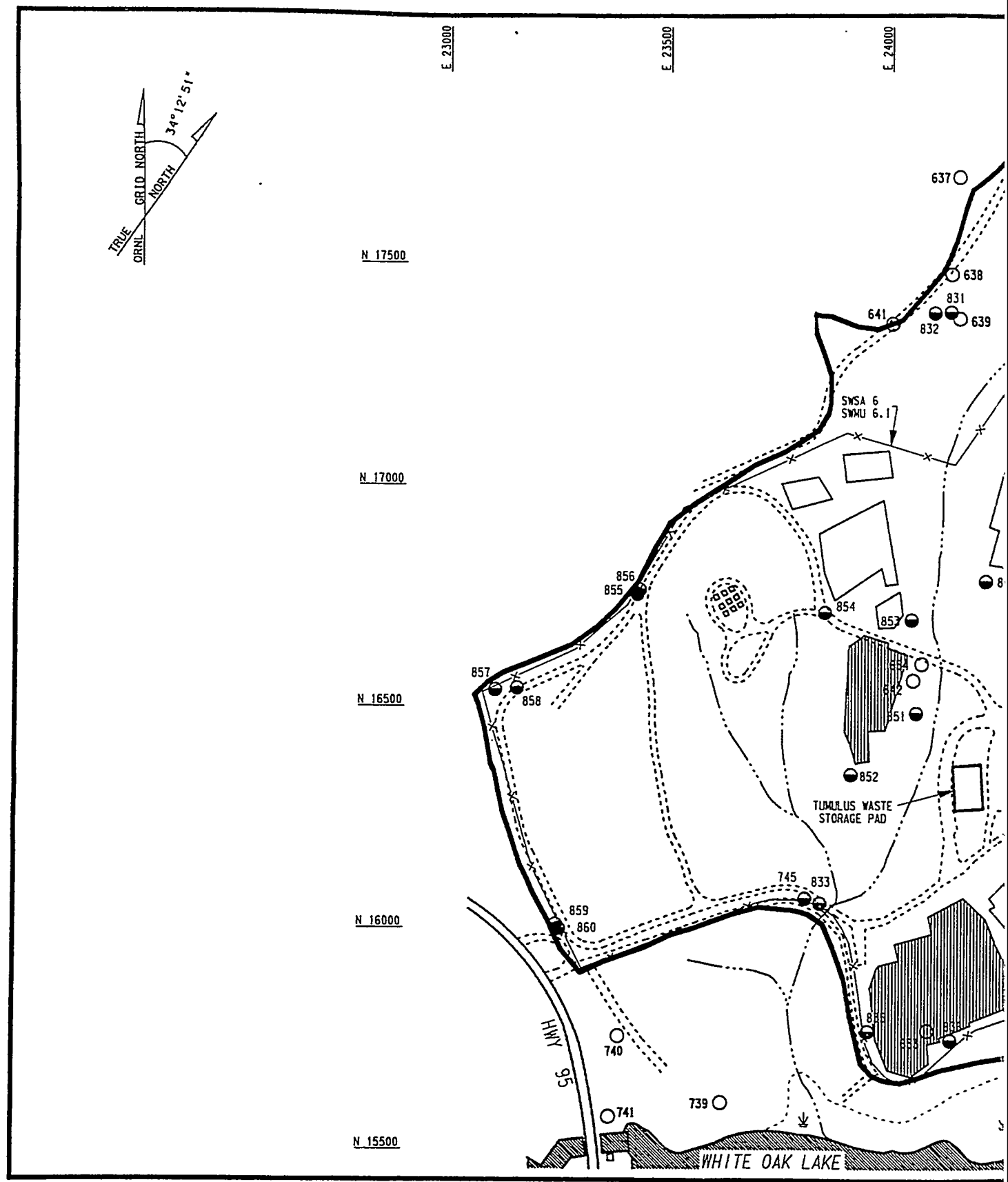
SWSA 6 LOCATIONS SAMPLED, PHASE II

Point	Location	Depth (ft)	Comment
Well 846	N18,030.72 E24,803.47	81	12/1
Well 844	N17,602.50 E25,228.63	52	12/1
Well 840	N16,928.59 E25,251.71	26.9	11/23 Samples at 5 min and RCRA(a)
Well 838	N16,308.66 E24,934.78	22.8	11/23
Well 850	N16,595.36 E24,793.45	22.7	11/23 Samples at 5 min and RCRA
Well 848	N16,942.37 E24,656.31	32.0	11/30
Well 836	N15,748.25 E24.138.75	28.5	11/28
Well 835	N15,767.69 E23,951.82	27.5	11/28
Well 833	N16,056.86 E23,842.37	31.0	11/28 Samples at 5 min and RCRA
Well 859	N16,009.43 E23,246.17	26.5	DRY no sample
Well 860	N15,999.59 E23,252.89	61.8	12/1 Samples at 5 min and RCRA
Well 857	N16,537.95 E23,106.31	70.0	11/29
Well 858	N16,542.09 E23,115.79	106.4	11/29 Samples at 5 min and RCRA
Well 832	N17,385.59 E24,096.73	85.9	12/1
Well 855	N16,755.35 E23,427.68	52.0	11/30

TABLE 5-17 (Continued)

Point	Location	Depth (ft)	Comment
Well 856	N16,764.41 E23,432.91	82.0	11/30 Samples at 5 min and RCRA
Surface Station 1	N/A	N/A	12/2
Surface Station 2	N/A	N/A	12/2
Surface Station 3	N/A	N/A	11/28
WOL 1	N/A	N/A	12/1 White Oak Lake Below Control Structure

(a) Samples were collected after a 5 minute purge (Standard Methods for the Evaluation for Water and Wastewater, American Public Health Association, 1975; Section 906A) and after a RCRA a specified purge (EPA, 1987).



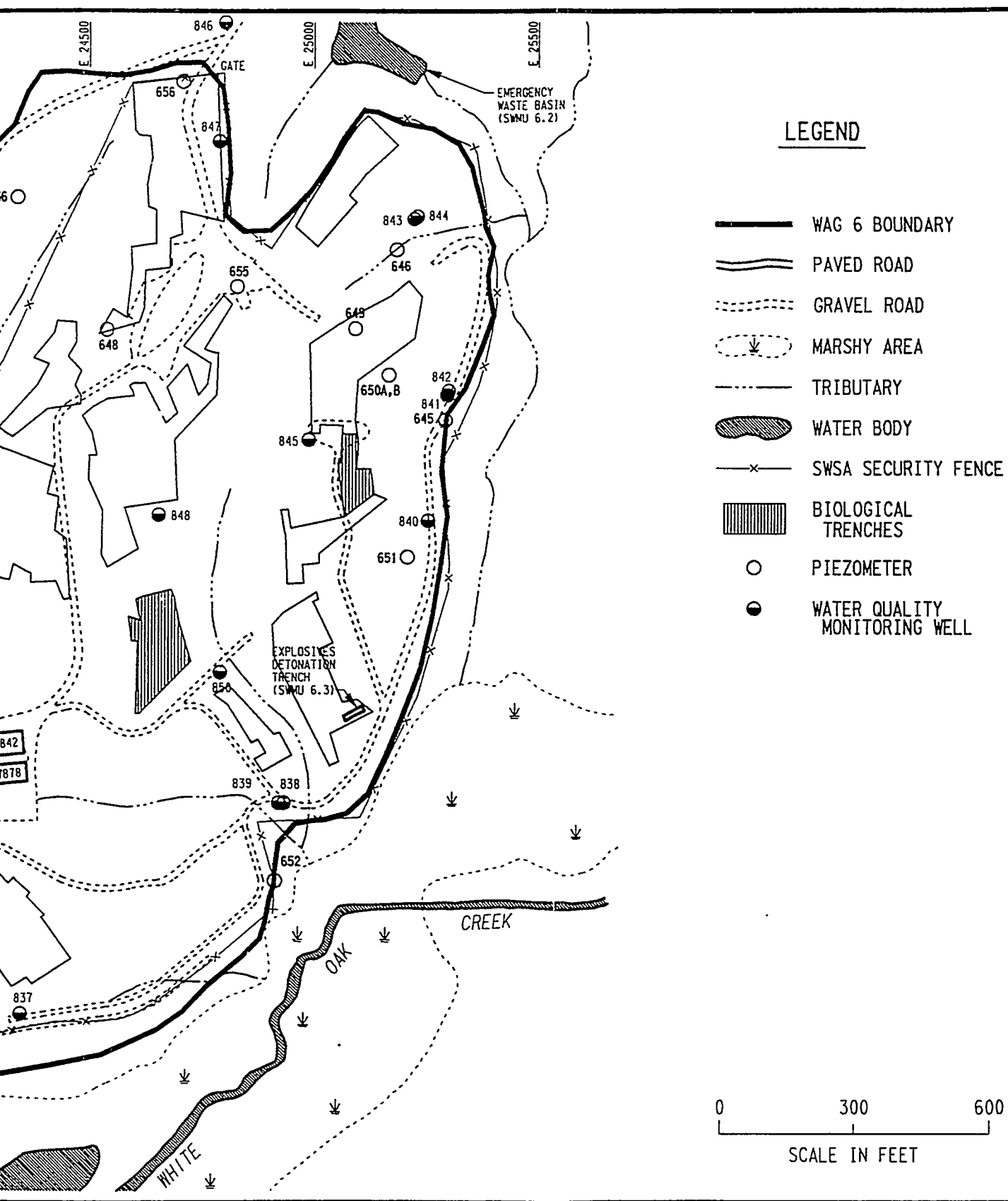


FIGURE 5-26
 PHASE 1 & 2
 MAP OF DOCUMENTED PIEZOMETERS
 AND WATER QUALITY WELLS

TABLE 5-18
BACTERIOLOGICAL PROFILE OF SAMPLES
FROM SWSA 6, PHASE II

Sample Well	Purge	Total Bacteria (CFU/mL)	Predominating Bacteria
316	840	5 ¹ (a)	9 x 10 ³ Pseudomonas, Pasteurella-like
317	Spike	1/450 ^(b)	6 x 10 ³ Pseudomonas, Klebrella, Bacillus, Flavobacter
318	850	RCRA ^(c)	1.9 x 10 ³ Pseudomonas, Flavobacter, Bacillus, Pasteurella-like
319	850	5 ¹	1.8 x 10 ³ Pseudomonas, Bacillus
320	838	5 ¹	2.6 x 10 ² Pseudomonas, Bacillus
321	840	RCRA	3 x 10 ³ Gram negative rod
322	Blank	Sterile ^(d)	<1 x 10 ² NA
323	No sample received, dry well		NA
324	833	RCRA	1.2 x 10 ⁴ Pseudomonas, Enterobacter
325	Sur 3	N/A	1.25 x 10 ⁴ Pseudomonas, Enterobacter, Citrobacter
326	835	5 ¹	7 x 10 ² Gram negative rod
327	836	5 ¹	<1 x 10 ² NA
328	833	5 ¹	<1 x 10 ² NA
329	Blank	Sterile	<1 x 10 ² NA
330	858	RCRA	3 x 10 ³ Pseudomonas, Pasteurella-like
331	858	5 ¹	2 x 10 ³ Pasteurella-like
332	860	RCRA	<1 x 10 ² NA
333	857	5 ¹	3 x 10 ² Gram negative rod
334	855	5 ¹	<1 x 10 ² NA
335	Blank	Sterile	<1 x 10 ² NA
336	Sur 1	N/A	1.7 x 10 ³ Pseudomonas, Enterobacter, Bacillus
337	856	RCRA	1.5 x 10 ³ Acinobacter, Flavobacter, Pasteurella-like
338	Sur 2	N/A	4.9 x 10 ³ Bacillus, Enterobacter
339	848	5 ¹	<1 x 10 ² NA
340	Roan 1	Roan ^(e)	5.5 x 10 ³ Pseudomonas, Proteus, Escherichin, Aeromonas
341	856	5 ¹	3 x 10 ³ Gram neg. rods, Pasteurella-like
342	Blank	Sterile	<1 x 10 ² NA
343	Blank	Sterile	<1 x 10 ² NA
344	832	5 ¹	1.2 x 10 ⁴ Gram negative rod
345	844	5 ¹	<1 x 10 ² NA
346	WOL 1	N/A	2.6 x 10 ⁴ Enterobacter, Escherichia, Pseudomonas
347	846	5 ¹	5 x 10 ² NA
348	860	5 ¹	<1 x 10 ² NA
349	Spike	1/500 ^(f)	1.1 x 10 ³ Pseudomonas
350	Blank	Sterile	<1 x 10 ² NA

(a) 5 minute pruge (Standard Methods for the Evaluation of Water and Wastewater, 1975).

(b) Spike 1 ml raw sewage in 450 ml water.

(c) RCRA PURGE (EPA, 1987).

(d) Sterile transfer.

(e) Deep off-site well.

(f) Spike 1 ml raw sewage in 500 ml water.

5.3.4 Conclusions

The second phase of microbiological sampling at SWSA-6 yielded results similar to those of the first phase. While no definitively pathogenic organisms were identified, with the possible exception of the Pasteurella-like bacteria, no conclusions can be made concerning the presence or absence of a biological hazard based on available data.

The Pasteurella-like organism that was discovered in Phase 1 was recovered in wider distribution in Phase 2. This bacterium did not express itself as a highly virulent organism in the animal testing performed; however, the findings on autopsy and the recovery of live bacteria from lung tissue is considered to be significant. It must be stressed that this organism has not been taxonomically identified and that the animal tests performed to date cannot be extended to man or other animals.

The absence of this organism in the site surface waters, the deep off-site well, or spikes prepared from sewage may indicate that the organism is unique to the local groundwater environment. Further evaluations of the distribution of this organism both on the ORNL Reservation and in the surrounding environment are necessary. Should the organism prove to be limited to the area of biological waste disposal or the ORNL Reservation, and if positive identification is not possible, additional testing to evaluate the disease producing potential of the organism will be required.

The public health impacts for this organism cannot be evaluated at this time.

5.4 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION

This subsection identifies contaminant source areas where the associated levels of environmental contamination exceed health

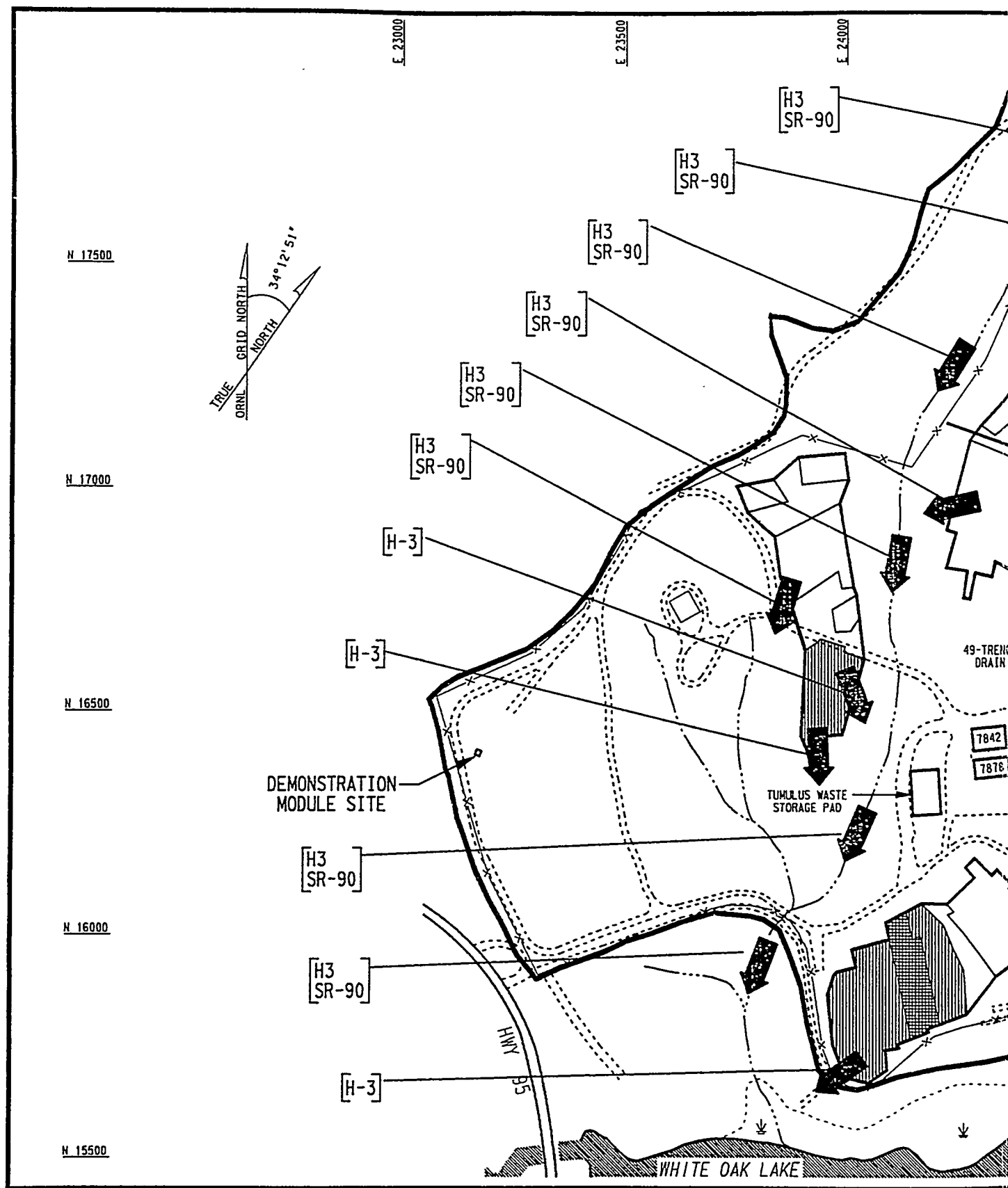
criteria derived in Section 7.0. As stated previously, the comparison with human health criteria is not performed in lieu of a site-specific risk assessment; it is performed to develop a preliminary list of compounds and source areas that may be most significant. Upon completion of the site-specific risk assessment, this section will be revised and included in the RFI Report.

Human health criteria have not yet been developed for a number of the contaminants detected at WAG 6, and consequently, an assessment regarding the possible significance of these compounds at WAG 6 has not been performed.

5.4.1 Radiological Contamination

The man-made radionuclides detected at WAG 6 are tritium, cobalt-60, strontium-90, cesium-137, plutonium-238, plutonium-239/240, americium-241, and curium-244. Human health criteria are available for only tritium and strontium-90. The concentrations of both radionuclides exceeded the criteria. Figure 5-27 shows the source areas at WAG 6 that appear to result in radionuclide environmental contamination above the criteria. The following areas at WAG 6 appear to be sources of radiological contamination above human health criteria developed in Section 7.0 (each area is listed along with the applicable radiological contaminants):

- o 17-Trench area (tritium)
- o East Waste Disposal Area; Northwest auger hole area (tritium)
- o Central Waste Disposal Area
 - High-activity trenches (tritium, strontium-90)
 - 49-Trench area (tritium, strontium-90)
 - Low-activity trenches northeast of 49-trench area (tritium, strontium-90)



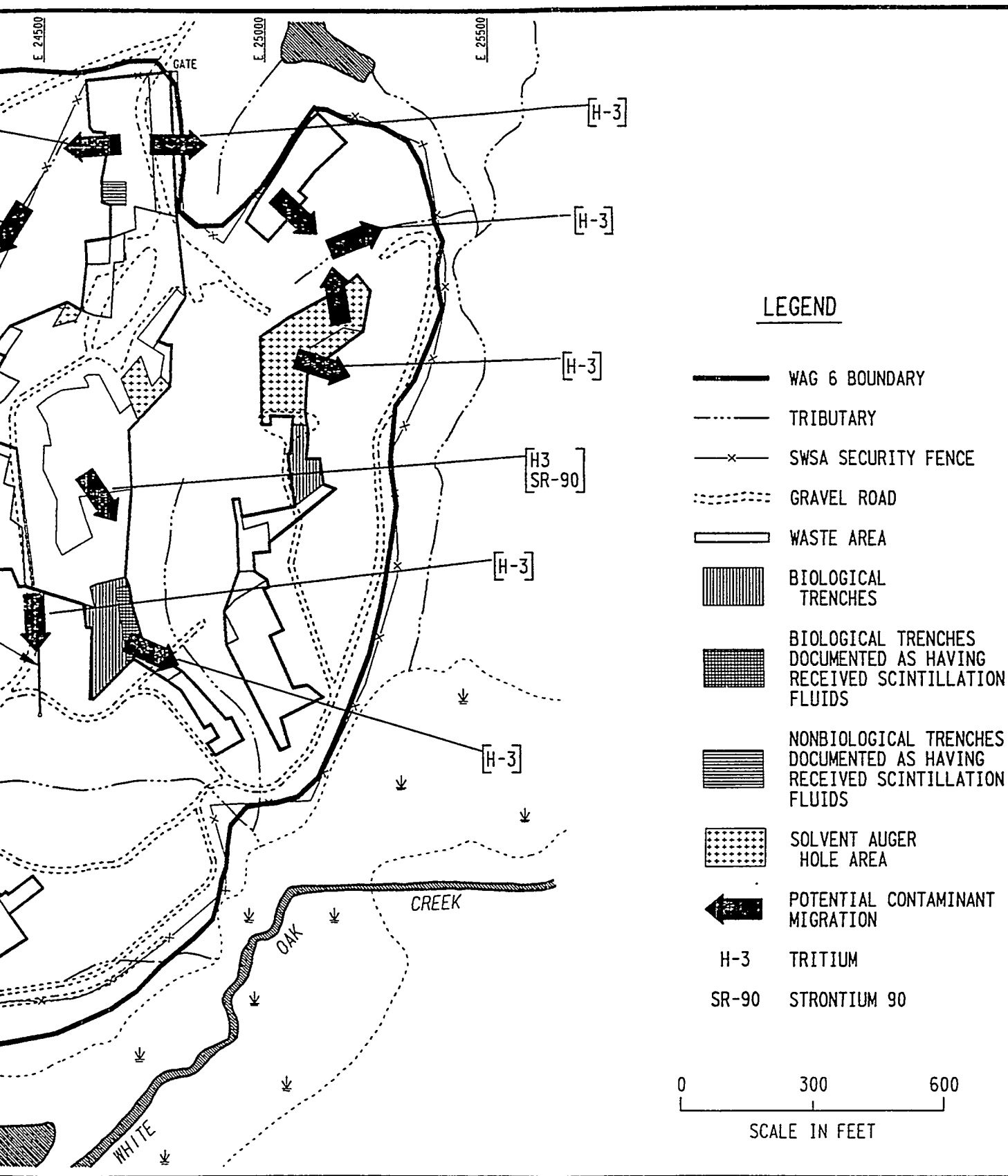


FIGURE 5-27
RADIONUCLIDES EXCEEDING
HUMAN HEALTH CRITERIA
IN WATER

- o West Waste Disposal Area
 - Low-activity trenches (tritium, strontium-90)
 - Biological trenches (tritium)
- o South Waste Disposal Area (tritium)

Note that the radionuclides were detected elsewhere on WAG 6, but levels were less than the human health criteria.

The naturally-occurring radionuclides detected at WAG 6 include potassium-40 and radionuclides belonging to the uranium series (uranium-238, thorium-234, uranium-234, thorium 230, radium-226), the thorium series (thorium-232, radium-228, thorium-228, and radium-224), and the actinium series (uranium-235). Human health criteria are available for total radium and uranium-234/238; only total radium exceeded the human health criteria (SDWA MCL) at some locations. Background data for naturally occurring radionuclides at ORNL are not yet available; consequently, it is unknown if the levels detected at WAG 6 are elevated with respect to background. Site-specific background samples have recently been collected and the data will be presented in the RFI report.

5.4.2 Chemical Contamination

Chemicals detected at WAG 6 are classified as either organic or inorganic constituents. The organic compounds detected are further classified as VOCs, SVOCs, and PCBs. The following 14 VOCs and 1 SVOC were detected at levels exceeding human health criteria:

- o VOCs
 - Chloroform (Trichloromethane)
 - Carbon Tetrachloride (Tetrachloromethane)
 - Vinyl Chloride (Chloroethene)
 - 1,2-Dichloroethene
 - Trichloroethene
 - Tetrachloroethene
 - 1,1-Dichloroethane
 - 1,2-Dichloroethane
 - 1,1,2-Trichloroethane

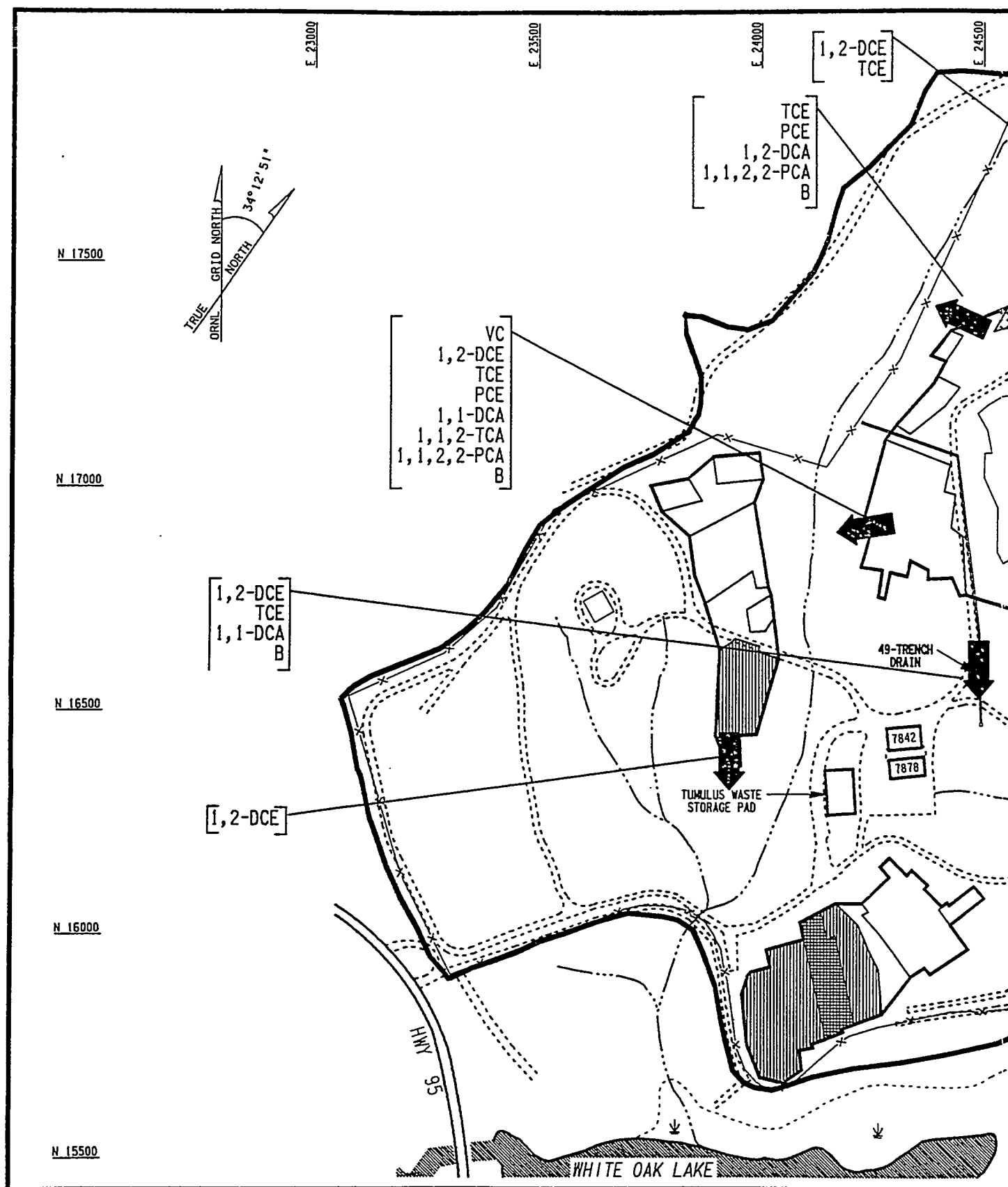
- 1,1,2,2-Tetrachloroethane
 - Benzene
 - Ethyl Benzene
 - Toluene
 - Xylene
- o SVOCs
 - Bis(2-ethylhexyl)phthalate

Figure 5-28 illustrates source areas for these compounds that appear to result in environmental contamination above human health criteria. The following areas at WAG 6 appear to be sources of chemical contamination above human health criteria developed in Section 7.0 (each area is listed along with the number of chemical contaminants detected exceeding health criteria):

- o 17-Trench Area (one VOC)
- o East Waste Disposal Area, Northwest Auger Hole Area (seven VOCs)
- o Central Waste Disposal Area
 - High-activity trenches (two VOCs)
 - Solvent auger hole area between low-activity silo area and high-activity silo area (four VOCs, benzene)
 - Solvent auger hole area on east side area (VOC)
 - 49-trench area (seven VOCs, benzene)
 - Low-activity trenches northeast of 49-trench area (one VOC)
 - Biological trench area (four BTX)
- o West Waste Disposal Area, Biological Trench Area (one VOC)

Note that the compounds identified were detected at locations other than those shown on Figure 5-28, but at levels less than human health criteria.

The levels of inorganic constituents detected in soils at WAG 6 fall within ranges of typical background values for the U.S. (Subsection 5.2.4.1). In groundwater and surface water, the human health criteria for drinking water were exceeded at approximately 12 groundwater and 3 surface water sampling locations. However, an analysis to determine if WAG 6 contains



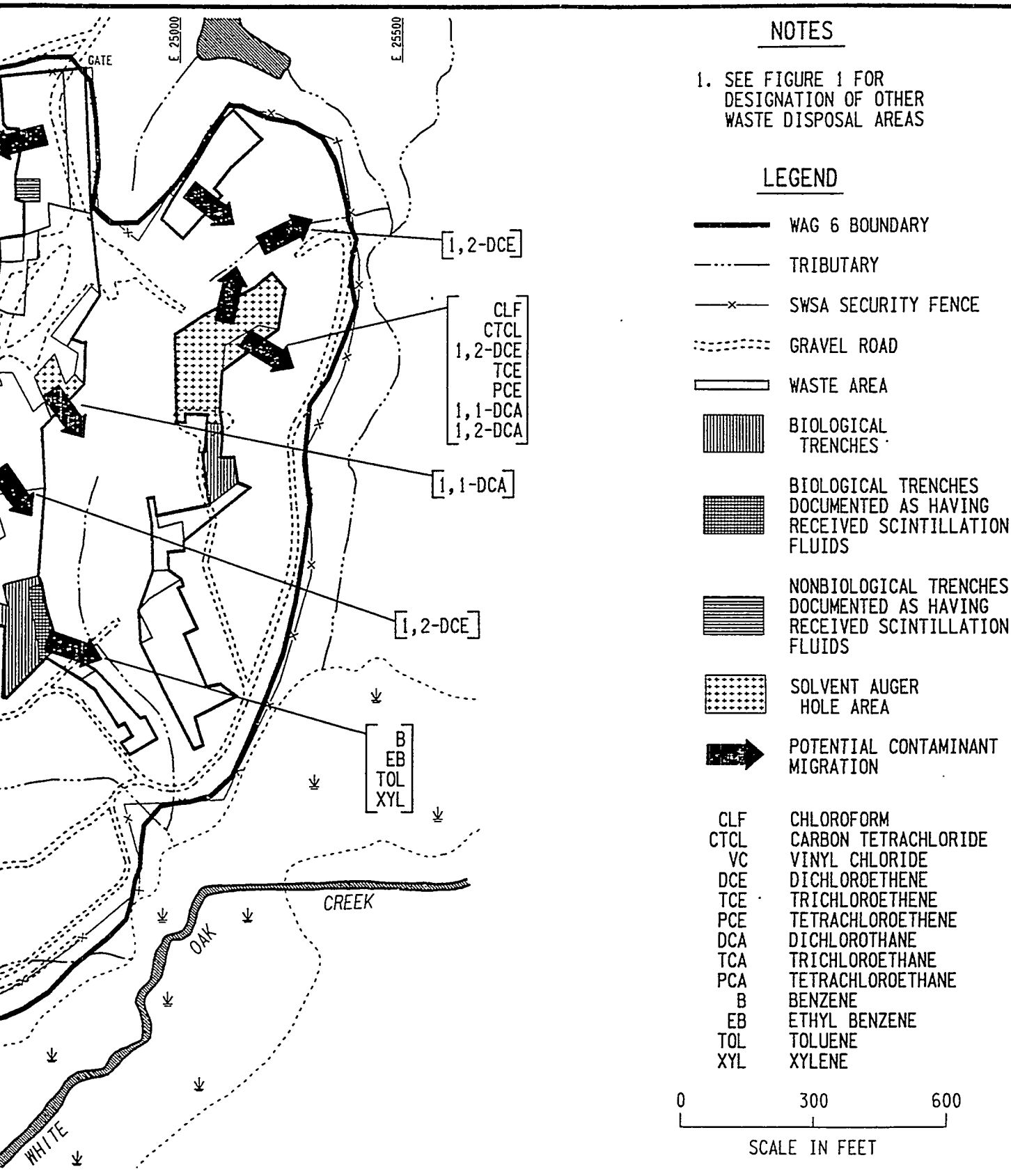


FIGURE 5-28
COMPOUNDS EXCEEDING
HUMAN HEALTH CRITERIA IN
GROUNDWATER & SURFACE WATER

elevated concentrations relative to natural background must await development of site-specific background data. This analysis will be presented in the WAG 6 RFI report.

5.4.3 Biological Contamination

During a limited investigation of potential microbiological hazards at WAG 6, no definitively pathogenic organisms were identified. The most significant finding was the discovery of a previously unidentified Pasteurella-like bacteria in groundwater samples from some wells. In laboratory experiments with mice, this bacterium did not appear to be highly virulent; however, live bacteria were recovered from lung tissue of infected mice.

The limited sampling and analysis performed to date indicate that the organism may be unique to the local groundwater environment. However, further evaluations of the distribution of this organism both on the ORNL Reservation and in the surrounding environment are necessary. The public health impact for this organism cannot be evaluated at this time.

6.0 CONTAMINANT FATE AND TRANSPORT

6.1 INTRODUCTION

This section discusses the methodology adopted to perform the fate and transport analysis in WAG 6. The methodology is based on the EPA Superfund Exposure Assessment Manual (U.S. EPA, 1988a). The fate and transport analysis in WAG-6 will be performed in two steps: (1) a screening mode and (2) a detailed evaluation. Both steps are quantitative in nature.

The purpose of the screening analysis is to determine exposure point concentrations. Potential risks from the contaminant sources will be discussed in Section 7.0. High-risk levels based on the screening analysis will warrant a detailed fate and transport analysis. The screening analysis uses analytical solution of groundwater flow and transport problems to determine the receptor-point concentrations based on reasonable worst-case scenarios of fate and transport. The reasonable worst-case scenarios will depend on site-specific conditions, which vary from source to source. After the completion of the screening analysis, the necessity to perform the detailed analysis using two- or three-dimensional numerical flow and transport models will be assessed. The criterion for this assessment is the estimated risk from the screening analysis. If the risks are lower than acceptable risk levels, as discussed in Section 7.0, no further analysis will be necessary. If the risks are significant, the in-depth modeling will be performed. Both screening and in-depth analysis are discussed in the EPA Superfund Exposure Assessment Manual (U.S. EPA, 1988a). The screening analysis is currently being conducted for selected areas within WAG 6. At this time, the analysis has been completed only for one area within WAG 6 which includes the majority of the auger holes. The auger hole area is located in the northeast corner of WAG 6 (Figure 6-1). The specific approach to this analysis is presented in this section along with

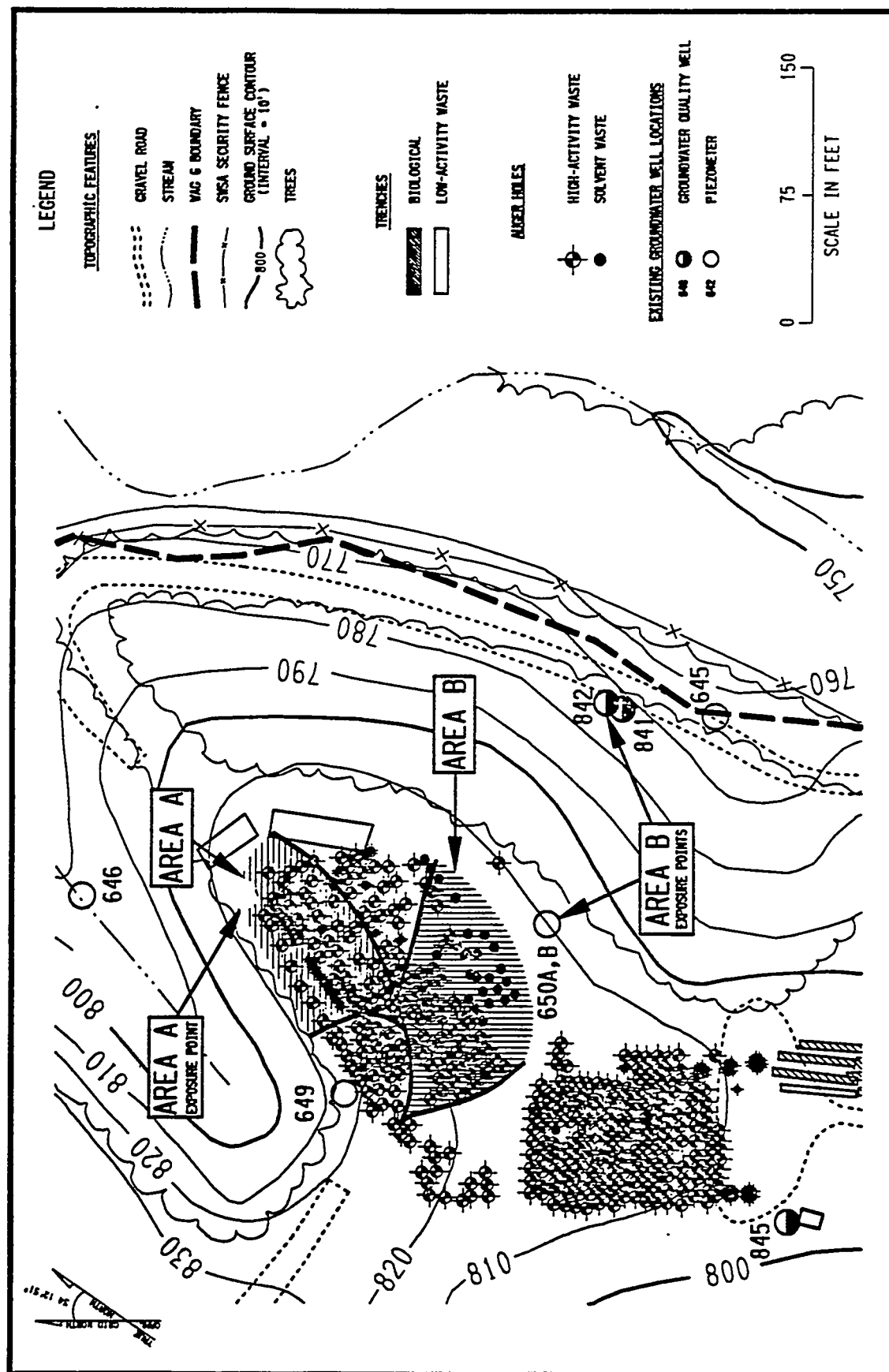


FIGURE 6-1
WAG 6 AUGER-HOLE AREA

13118 06 09 000

results of the analysis and conclusions. The specific approach for screening analysis at other areas may not be identical to the one at the auger holes. However, the general approach discussed below will be followed for all areas.

6.2 GENERAL APPROACH TO SCREENING ANALYSIS IN WAG 6

The screening analysis in WAG 6 will involve the following sequential steps:

- 1) **Analysis-area determination.** WAG 6 contains a number of radioactively and chemically contaminated disposal units comprised of trenches and auger holes. Based on their locations, a number of areas can be isolated and each can be defined by its own watershed and discharge boundaries. Each area can be modeled independently of the other in a screening analysis. The hydrogeologic interrelationship of these individual areas will be addressed by the in-depth analysis, if required.
- 2) **Source-term determination.** The source-terms for the surface and groundwater pathways will be estimated on the basis of: (a) waste form and history of disposal, (b) contaminants present in the waste forms and their inventories, and (c) applicable leaching mechanisms based on the conceptual model presented in Section 4.0. The vertical location of the disposal unit, either auger hole or trench, with respect to the water table, will be used to estimate source terms based on such phenomena as bath-tubbing of the trench, zero/partial/full submergence of the trench, etc. Contaminant inventory data for chemicals is essentially nonexistent while radionuclide inventories exist for specific auger holes and trenches. Reported activity, disposed in trenches and auger holes, may be off by an order of magnitude.
- 3) **Exposure Point Identification.** One or more exposure-points will be identified for the screening on and around a source on the basis of local topography for both surface and groundwater pathways. Other exposure-points will be established based on scenarios described in Section 7.0. The exposure-points will be placed at a topographic low to which both waters are assumed to flow. Where evidence is available on a preferential, along-strike flow of groundwater, additional exposure-points will be placed in that direction.
- 4) **Groundwater pathway.** The exposure-point concentration will be calculated by considering the transport of contaminants in the vadose zone and the shallow saturated zone. Contaminant movement is assumed to be vertical in the vadose zone and down-gradient in the saturated zone and will be modeled using

analytical methods. Site-specific conditions will determine the specific analytical models to be used. The effective saturated zone thickness (for vertical mixing and dilution) will be estimated on the basis of the proximity of the receptor to the source.

- 5) Surface water pathway. The exposure-point concentration will be calculated on the basis of contaminant transport by surface runoff; the sediment transport component will also be addressed. As with the groundwater pathway, specific analytical methods will be chosen on a site-specific basis.
- 6) Air pathway. The exposure-point concentration will be calculated by considering the transport of contaminants in the air. The initial screening efforts have not yet included the significance of the air pathway.
- 7) Comparison with current data and calibration. The results of the screening analysis will be compared with current observations of groundwater and surface water quality; model calibration will be performed using the data to further develop reasonable worst-case predictions for future scenarios.
- 8) Uncertainty analysis. Uncertainties in the screening analysis will be addressed through error analysis studies to estimate the accuracy and parameter dependency of model-predictions.

6.3 APPLICATION OF THE SCREENING APPROACH

The auger-hole area was selected as the first area for the screening analysis because the majority of radionuclides disposed of at WAG 6 was contained in this area. The area is divided into several smaller regions such that a single off-auger hole receptor would account for all the groundwater and surface water discharges in that region. The analyses for two regions, marked as areas A and B in Figure 6-1, are discussed below.

6.3.1 Source Definition

Figure 6-1 illustrates the auger hole area and its surrounding features. Over 500 auger holes are located in the auger hole area, in which auger hole diameters range from 10 to 47 in. In most cases, auger holes are greater than or equal to 30 in. in diameter. ORNL reports have indicated that most of the waste was

placed within 55-gal drums or in the case of smaller diameter auger holes, 5-gal cans, prior to burial. The wastes within the drums included radioactively contaminated pipes, gauges, and other assorted materials that may have been cut up to fit into the drums. Sixteen of the auger holes contain over 80 percent of the total activity in the auger-hole area.

The auger hole area is situated on a topographic high and is bounded by ephemeral surface drainage features. In this area, the groundwater flow has been assumed to follow surface water runoff flow directions. Water level records from nearby piezometers and monitoring wells and potentiometric head contour maps indicate that the water table is at approximately 790 ft (Davis, 1987) above mean sea level. The ground surface elevation ranges from approximately 823 ft in the northern part to 808 ft in the most southernmost part of the auger hole area (Figure 6-1). The topography slopes eastward to approximately 780 ft near well #842.

Auger holes were typically drilled to depths of 15 to 18 ft or to within 2 ft of the water table, whichever was less. For purposes of the screening approach presented, the auger holes were assumed to be 18 ft deep and their bottoms 1 ft above the water table. This scenario matches Case II in Section 4.0, in which the auger hole is located in the vadose zone and above the water table. Screening calculations using the 1 ft separation between the auger hole bottom and the groundwater represents a reasonable worst-case situation. Two areas, A and B, within the auger-hole area have been analyzed using the screening approach. These areas were chosen based on their location with respect to the direction of groundwater flow and on the number of auger holes that could be grouped together to act as a source. Each area is addressed in detail in the following subsections.

6.3.1.1 Area A. There are 74 auger holes within Area A, as listed in Table 6-1. After reviewing the waste inventory (Davis

TABLE 6-1

RADIONUCLIDE INVENTORY FOR AUGER HOLES IN AREA A¹

Hole no.	Type of auger hole	Year closed	Hole diam (in)	Hole depth (ft)	Total curies (5/21/86) from mod 1-3 ²	Unid	H-3	Co-60	Sr-90	Cs-137	Eu-152
24-29	High Level	1974	30								
34-39	High Level	1974	18								
40	High Level	1974	18								
41	High Level	1975	36								
44-50	High Level	1974	10								
51-55	High Level	1974	18								
56-60	High Level	1974	30								
62-63	High Level	1974	30								
75	High Level	1975	30								
*	High Level	1975	47								
97	High Level	1975	47								
99	High Level	1975	47			5	0	0	0	0	0
110-113	High Level	1976	47								
118-119	High Level	1976	47								
121	High Level	1976	47								
130-134	High Level	1976	47								
135	High Level	1976	12								
144	High Level	1977	12								
154	High Level	1977	47			0.001	0	0	0	0	0
166	High Level	1977	47		118.15	118	0	0.15	0	0	0
168	High Level	1978	47	8	1060.70514	0.1	0	1000	0	2	2
174	High Level	1978	47	8	16.6	0	0	13.6	0	0	3
180	High Level	1978	47		1320	1300	0	0	5	15	0
201	High Level	1979	47		35.1	0.1	0	0	20	15	0
204	High Level	1979	47		50.1	5.1	0	0	17.5	20	0
205	High Level	1979	47		30.2	2.2	0	12	6	10	0
211	High Level	1979	47		5.25	0	0	1.75	1.75	1.75	0
212	High Level	1979	47		1.51	1.01	0	0.5	0	0	0
214	High Level	1979	47		5.82	0.62	0	3.3	1.1	0.6	0
217	High Level	1979	47		12.011	0.001	0	10	1	1.01	0
223	High Level	1980	36	12	0.130085899	0.1	0	0.00001	0	0.03	0
					1.75	1.75	0	0	0	0	0
Total curies in area A:					6162.3272	1433.982	0	1041.30001	52.35	65.39	5

¹ A blank space indicates information was not reported in the Davis and Solomon report. Source: Davis and Solomon (1987).

² Note that the total curies for specific auger holes may not add up due to certain radionuclides not shown on this table (e.g. SM-151).

* Auger holes 83, 86, 87, 88, 89, 91, 92, and 95.

and Solomon, 1987), Area A was split into three groups of auger holes due to the inventory values and availability of inventory data for the 74 auger holes. Only 14 auger holes had available inventory data, while 60 auger holes lacked documented data describing the amount of radioactivity disposed in each hole. Two auger holes, 166 and 174, contain the majority of the curie content disposed in Area A. These two auger holes were modeled by placing one "centroid" auger hole between the two and calculating concentrations for specific radionuclides at the edge of the auger hole area. Lack of calibration data directed the screening efforts to Area B. Modeling results for Areas A and B are discussed later.

6.3.1.2 Area B. Area B contains 75 auger holes (Table 6-2), 52 of which are similar to those described in Area A and 23 solvent auger holes. Solvent auger holes do not have available inventory on chemicals or radionuclides. Solvent wastes have been identified as acids, cleaning solutions, alcohols, paint thinners, kerosene, jet fuel, sodium, and miscellaneous solvents and other chemicals. Some of the solvents were reported to be radioactively contaminated. For this reason, they were not utilized quantitatively for the screening effort but were used qualitatively (see Section 6.4). All but 8 of the 52 auger holes had radionuclide inventories for total curies and individual radionuclides that make up the totals. An average curie content for each radionuclide found in the inventory list was assigned to each of the 8 unknown auger holes. The average curie value for each radionuclide was determined by averaging inventories for all the auger holes (excluding the 16 extremely high-level auger holes mentioned previously) in the auger hole area. One high curie content auger hole (#236) was located in Area B. This auger hole was then assumed to be the centroid representing all auger holes in Area B.

Although the waste inventory (Davis and Solomon, 1987) is reported to be inaccurate, with a potential to be off by an order

TABLE 6-2

RADIONUCLIDE INVENTORY FOR AUGER HOLES IN AREA B¹

Hole no.	Type of auger hole	Year closed	Hole diam (in)	Hole depth (ft)	Total curies (5/21/86) from mod 1-32	Unid	H-3	Co-60	Sr-90	Cs-137	Sm-151	Eu-152	Eu-154	Eu-155
124	High Level	1976	47	8	148.4	7.4	0	141	0	0	0	0	0	0
156	High Level	1977	47		6.4000998	5.6	0	0	0.2	0.2	0	0	0	0
188	High Level	1979	47		10.200998	0.2	0	0.000998	5	0	0	0	0	0
189	High Level	1979	47		0.00000128	0	0	0	0	0	0	0	0	0
190	High Level		15		38.000347	30	0	8	0	0	0	0	0	0
191	High Level		15											
192-195	High Level		15											
208	High Level	1979	47		7.252	3.25	0	0	1	1.5	0	0	0	0
209	High Level	1979	47		4.2	0.2	0	2	1	1	0	0	0	0
213	High Level	1979	47		4.02	0.02	0	0	2	0	0	0	0	0
215	High Level	1979	47		24.5	20.2	0	0	0.7	0.2	0	0	0	0
218	High Level	1980	47		31.001	0.001	0	0	11	20	0	0	0	0
222	High Level	1980	47		81.75	52.5	0	0	1.75	27.5	0	0	0	0
224	High Level	1980	36		103.75	22.5	30	0	1.25	50	0	0	0	0
225	High Level	1980	36		11.1	11.1	0	0	0	0	0	0	0	0
226	High Level	1980	36		53	12	0	20	1	20	0	0	0	0
227	High Level	1980	36		209.8	7.8	0	0	1	201	0	0	0	0
229	High Level	1980	36		15	5	0	0	5	0	0	0	0	0
230	High Level	1980	36		44	3	0	20	6	15	0	0	0	0
231	High Level	1980	47		55	25	0	10	10	0	0	0	0	0
232	High Level	1980	47											
233	High Level	1980	47		10.1	10.1	0	0	0	0	0	0	0	0
236	High Level	1980	24		47080.002	0.002	0	0	0	0	16200	22300	8580	0
237	High Level	1980	47		15.018	0.018	0	0	5	10	0	0	0	0
238	High Level	1980	47		31	10	0	0	17.5	3.5	0	0	0	0
239	High Level	1980	47		30.103	0.103	0	0	25	5	0	0	0	0
240	High Level	1980	47		55.01	0.01	0	0	50	5	0	0	0	0
248	High Level	1980	47		676.8000514	0.2	0	450	75.2	101	50.2	0	0	0
251	High Level	1980	47		91.36	26.5	0	0	7.3	7.36	5	40.2	0	0
252	High Level	1980	47		26.51	1.1	0	2	0.11	1.1	20	0	0	0
253	High Level	1980	47		23.5	23.5	0	0	0	0	0	0	0	0
254	High Level	1980	47		85	7.5	0	60	5	10	2.5	0	0	0
255	High Level	1980	47		55	55	0	0	0	0	0	0	0	0
256	High Level	1980	47		15	15	0	0	0	0	0	0	0	0
257	High Level	1980	47		30	20	0	0	5	0	0	0	0	0
258	High Level	1981	47		23	23	0	0	0	0	0	0	0	0
259	High Level	1981	47		38	38	0	0	0	0	0	0	0	0
260	High Level	1981	47		35	15	0	0	10	10	0	0	0	0
261	High Level	1981	47		42.5	10	0	0	12.5	20	0	0	0	0

TABLE 6-2 (Continued)

Hole no.	Type Of auger hole	Year closed	Hole diam (in)	Hole depth (ft)	Total curies (5/21/86) from mod 1-3 ²	Unid	H-3	CO-60	SR-90	CS-137	SM-151	EU-152	EU-154	EU-155
262	High Level	1981	47		5	0	0	0	2.5	2.5	0	0	0	0
274	High Level	1981	47		115.5	15.5	0	100	0	0	0	0	0	0
277	High Level	1981	47		276	1	0	200	0	70	5	0	0	0
280	High Level	1981	47		27	22	0	0	0	3	2	0	0	0
281	High Level	1981	47		39.19	4.19	0	30	0	5	0	0	0	0
282	High Level	1981	47		36	31	0	5	0	0	0	0	0	0
338	High Level	1983	36		122.7	0	0	89.7	0	33	0	0	0	0
TOTAL CURIES IN AREA B:					49831.66749	534.494	30	1137.700998	262.01	652.86	67.2	16260.2	22300	8580

¹ A blank space indicates information was not reported in the Davis and Solomon report. Source: Davis and Solomon (1987).

² Note that the total curies for specific auger holes may not add up due to certain radionuclides not shown on this table (e.g. SM-151).

of magnitude, the total curies per radionuclide for all 52 auger holes was assigned to the centroid. The summation of the auger hole bottom areas was also assigned to the centroid. Again the bottom of the auger holes were assumed to be 1 ft above the water table.

6.3.2 Pathways Modeled

In considering the risk to a receptor from an auger hole area, the dominant pathway would be the groundwater pathway via an existing well. Any contaminated surface water originating in the auger hole area would only appear following a runoff-producing storm. For purposes of this screening analysis, only the groundwater pathway was investigated. The pathway can be described as follows: the vertically percolating water resulting from precipitation will leach the contaminants from the auger hole, traverse the vadose zone vertically to mix with the down-gradient flow of groundwater in the saturated zone to ultimately reach the exposure point.

6.3.3 Exposure Point Locations

The exposure point locations described below are shown in Figure 6-1 for Areas A and B. Note that two exposure points are indicated near Area B, one of which is located at the ORNL compliance monitoring well 842. The groundwater quality data from this well will be used to calibrate the analytical model in Area B. The other exposure point (piezometer 650) is placed closer to the source at the boundary of the auger hole region.

6.3.4 Models and Assumptions

6.3.4.1 Leaching. Deep percolation of infiltrating rainwater through the waste form results in the leaching of contaminants. It is assumed that the cap that currently exists on the auger hole area has completely deteriorated. The waste forms in Areas A

and B, as described earlier, consist of contaminated pipes and fittings which were placed in 55-gal drums, which in turn were placed in the auger holes. The drums are assumed to deteriorate completely in 50 years. A leaching fraction F controls the amount of contaminant coming in contact with water. Once the water comes into contact with the contaminant, the leaching can proceed by sorption- or solubility-controlled mechanisms. Since more reliable data are available for the distribution coefficients (K_d) rather than the solubilities, a sorption-controlled leaching approach is being used. It is assumed that the concentrations of the radionuclides are uniform over the entire depth of the auger hole. It is further assumed that the water leaving the auger hole leaves at the equilibrium concentration of the radionuclide determined by the K_d and the amount of the radionuclide present in the auger hole.

In Area A, one simulation run was conducted for auger holes 166 and 174. In Area B, a single source term was used for all the radioactively contaminated auger holes in the area. The cross-sectional area of the resultant single auger hole is the sum of the individual auger hole cross-sectional areas. The sources have already been discussed in detail in the previous sections.

The geometric mean darcy velocity for water percolation in the vadose zone is obtained from Moore (1988) as 1.1 m/y. The thickness of the vadose zone is assumed to be 1 ft as a conservative value. From the leaching assumptions described earlier, the inflow of contaminants to the vadose zone at the bottom of the auger hole is evaluated as :

$$Q_0 = I C_w A \quad (1)$$

where Q_0 = the rate of contaminant recharge to the vadose zone from the auger hole (Ci/y),
 I = the water percolation rate through the auger hole (m/y),

C_w = concentration of the contaminant in the percolating water at the bottom of the auger hole (C_i/m^3), and
 A = effective cross-sectional area of the combined auger holes (m^2).

The contaminant concentration in the auger hole at any time is calculated as:

$$C_w = FM/[V_A(PORVA*SSAT+BDENS*KDA)] \quad (2)$$

where F = the leaching fraction for the contaminant in the auger hole,
 M = current inventory of the radionuclide in the auger hole (C_i),
 V_A = the volume of the auger hole (m^3),
 $PORVA$ = total porosity in the auger hole,
 $SSAT$ = degree of saturation,
 $BDENS$ = host formation bulk density of the auger hole material (kg/m^3), and
 KDA = distribution coefficient of the radionuclide in the auger hole (m^3/kg).

6.3.4.2 Transport of contaminants. The transport of radionuclides in the vadose zone and in the saturated zone is evaluated using Hung's groundwater transport model (Hung, 1986). The basic equations of the model as adopted from Hung (1986) are as follows:

$$Q = Q_0 (T-RL/V) \text{ Exp}(-\lambda t) \quad (3)$$

and

$$z = \text{Exp}(P/2 - P/2 \sqrt{1+4RL/PV}) / \text{Exp}(-RL\lambda/V) \quad (4)$$

where

z = a correction factor to compensate for the dispersion effect,
 R = retardation factor, R_v or R_H ,
 P = Peclet number, $V_v D_v/d$ or $V_H D_H/d$,
 L = flow length, D_v or D_H (m),
 V = water flow velocity, V_v or V_H (m/y),
 t = transit time, t_v or t_H ,
 d = dispersion coefficient (m^2/y),
 λ = radiological decay constant (y^{-1}),
 Q = rate of radionuclide transport at distance L from the source (C_i/y),

Q_0 = rate of radionuclide transport at the source (Ci/y),
 T = time of simulation (y),
 subscript V= vadose zone, and
 subscript H= shallow saturated zone.

Equation (3) is applied to the vadose zone and the shallow saturated zone at any time step. When applied to the vadose zone, Q_0 is obtained from Equation (1) and when applied to the saturated zone, the Q_0 is obtained from Equation (2) obtained after the application in the vadose zone.

The vertical water flow velocity through the vadose zone is obtained as

$$V_V = I/EPORV \quad (5)$$

where EPORV is the effective porosity in the vadose zone. The down gradient water velocity through the shallow saturated zone is obtained from

$$V_H = \frac{K_H \text{ GRAD}}{EPORA} \quad (6)$$

where K_H = the hydraulic conductivity of the shallow saturated zone (m/y),

GRAD = the hydraulic gradient in the shallow saturated zone, and

EPORA = the effective porosity in the shallow saturated zone.

To calculate the radionuclide concentration at the receptor, the rate of groundwater flow in the plume of contamination at the receptor point is calculated by

$$W_A = V_H P_A D_A [\sqrt{A} + 2 \tan(a/2) D_H] \quad (7)$$

where

W_A = the rate of contaminated water available for removal at the receptor point (m^3/yr).
 V_H = groundwater velocity (m/y),
 P_A = porosity of the shallow saturated zone,
 D_A = effective thickness of the flow domain in the shallow saturated zone (m),
 a = angle of spread of the contaminant plume in the shallow saturated zone (radians),

A = projected cross-sectional area of the auger holes
(m²), and
D_H = distance to the receptor (m).

The effective thickness of the saturated zone is used in Equation (7) instead of the overall saturated zone thickness because the proximity of the receptor to the source would result in only a part of the saturated zone being contaminated (depending on the vertical dispersivity). Therefore, conservative values of D_A are chosen for the Areas A and B. Similarly the angle of dispersion was chosen conservatively as 0.3 radians. Water flow rates in the Vadose zone and the saturated zone were obtained from Moore (1988).

The radionuclide concentration at the exposure point is calculated by

$$C_{WL} = Q/W_A \quad (8)$$

where C_{WL} is the concentration of the radionuclide in the groundwater at the receptor location (Ci/m³).

In Equation (4), R_V and R_H are calculated as

$$R_V = 1 + (BDENS * KDV) / (PORV * SSAT) \quad (9)$$

and

$$R_H = 1 + (BDENS * KDH) / PORA \quad (10)$$

where

KDV = distribution coefficient of the radionuclide in the vadose zone (m³/kg),

KDH = distribution coefficient of the radionuclide in the shallow saturated zone (m³/kg) and

PORA = porosity in the shallow saturated zone soil.

The vertical and horizontal transit time, t_V and t_H, are calculated as

$$t_V = D_V R_V / V_V \quad \text{and} \quad t_H = D_H R_H / V_H. \quad (11)$$

The input parameters for the simulations made for Areas A and B are presented in Tables 6-3 and 6-4, respectively.

6.4 RESULTS AND DISCUSSION

6.4.1 Area A

Model simulations indicate that only two radionuclides, Co-60 and Sr-90, would show up at the exposure point location within 130 years. However, only one simulation was run using the two auger holes with the highest amount of activity (166 and 174). No soil/groundwater data were available at or near the exposure point location. Therefore, model calibration, especially for leaching fraction (F) and distribution coefficient (K_d), could not be performed. It was decided to stop simulation in this area until a similar auger hole location was found in WAG 6 where soil/groundwater quality data exist and where the model can be calibrated before being implemented in Area A.

6.4.2 Area B

Area B discharges to a creek on the southeast boundary with ORNL compliance monitoring well 842 located approximately 68 m downgradient from the auger holes. The data from this well indicate Co-60, H-3, Sr-90, and Cs-137 to be present in the groundwater at concentrations of 267, 675,000, 0.2, and 12 pCi/L, respectively. An initial simulation of the model resulted in no radionuclides showing up at the well in 70-80 years. Based on the knowledge that Co-60 complexes with organic ligands and moves considerably faster with low retardation in the soil (WAG-7 RI Plan), it was decided to lower the K_d of Co-60 until it shows up in the well in 7 years. Figure 6-2 illustrates the predicted concentrations of Co-60 arriving at well #842 over time. A value of 1.2 mL/g was arrived at by a trial and error process. Results of Killey et al. (1984) indicates that K_d of Co-60 can go down to 0.5 mL/g in the presence of organic solvents. Olsen et al. (1986)

TABLE 6-3

INPUT PARAMETERS FOR AREA A SIMULATION

1. Radionuclides considered : Co-60, Sr-90, Zr-93, Cs-137, Sm- 151, Eu-152,
2. Auger hole cross-sectional area : 2.24 m²,
3. Depth of the auger hole : 4.6 m,
4. Fraction of radionuclides being leached between year 1 and 50 : 1.E-5
5. Fraction of radionuclides being leached at year 150 : 1.0
6. Nuclide data

Nuclide	Initial Inventory (Ci)	decay constant (y ⁻¹)	K _d in soil (mL/g)	K _d in auger hole (mL/g)
Co-60	1000	0.132	45	45
Sr-90	5	0.0242	35	35
Zr-93	0.005	7.296E-7	3000	3000
Cs-137	17	0.023	1000	1000
Sm-151	55	0.0075	650	650
Eu-152	2	0.0546	650	650

7. Seepage percolation rate : 73 m/y
8. Vadose zone travel distance : 0.3 m
9. Distance from source to receptor : 12.2 m
10. Vadose zone total porosity : 0.5
11. Auger hole porosity = 0.5
12. Vadose zone effective porosity = 0.015
13. Vadose zone degree of saturation : 0.9
14. Bulk density of soils : 1500 kg/m³
15. Dispersion length : 0.3 m

TABLE 6-3 (continued)

INPUT PARAMETERS FOR AREA A SIMULATION

-
16. Effective thickness of shallow saturated zone : 3 m
 17. Total porosity of shallow saturated zone : 0.5
 18. Effective porosity of the shallow saturated zone: 0.024
 19. Groundwater velocity : 120 m/y
 20. Horizontal angle of dispersion : 0.3 radians
-

TABLE 6-4

INPUT PARAMETERS FOR AREA B SIMULATION

1. Radionuclides considered : Co-60, Sr-90, Cs-137, Eu-152, Eu-154, Eu-155, H-3
2. Auger hole cross-sectional area : 47 m²,
3. Depth of the auger hole : 4.6 m
4. Fraction of radionuclides being leached between year 1 and 20 : 1.61E-5
5. Fraction of radionuclides being leached at year 130 : 1.0
(for H-3 F is 0.00172 at all times)
6. Nuclide data

Nuclide	Initial Inventory (Ci)	decay constant (y ⁻¹)	K _d in soil (shallow saturated zone) (mL/g)	K _d in auger hole (mL/g)	K _d in soil (vadose zone) (mL/g)
Co-60	1302	0.132	1.2	45	45
Sr-90	327	0.0242	35	35	35
Cs-137	799	0.023	1000	1000	1000
Eu-152	16272	0.0546	650	650	650
Eu-154	22305	0.0889	650	650	650
Eu-155	8580	0.1386	650	650	650
Sm-151	74	0.0075	650	650	650
H-3	70	1.55E-4	0	0	0

7. Deep percolation rate : 73 m/y
8. Vadose zone travel distance : 0.3 m
9. Distance from source to receptor : 68.6 m
10. Vadose zone porosity : 0.5
11. Auger hole porosity = 0.5
12. Vadose zone effective porosity = 0.015
13. Vadose zone degree of saturation : 0.9
14. Bulk density of soils : 1500 kg/m³
15. Dispersion length : 0.3 m

TABLE 6-4 (continued)

INPUT PARAMETERS FOR AREA B SIMULATION

- 16. Effective thickness of shallow saturated zone : 3 m
 - 17. Total porosity of shallow saturated zone : 0.5
 - 18. Effective porosity of the shallow saturated zone: 0.024
 - 19. Groundwater velocity : 47 m/y
 - 20. Horizontal angle of dispersion : 0.3 radians
-

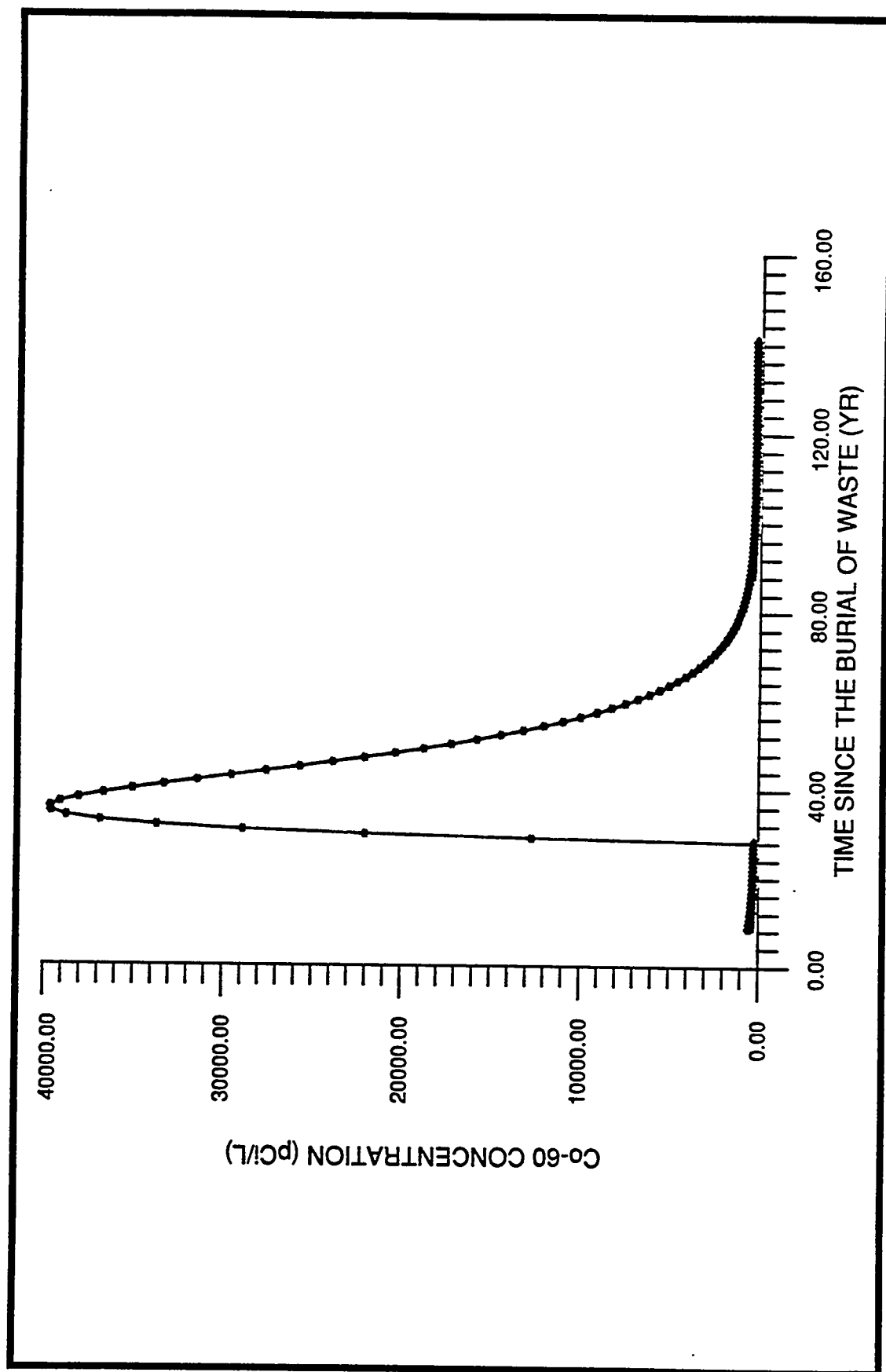


FIGURE 6-2
Co-60 CONCENTRATION IN WELL #842

have indicated that Co-60 solution complex is organic in nature, and most of it is usually bound to low-molecular weight complexes. In the Trench 7 (WAG 7) area, they have suggested that the enhanced mobility of Co-60 occurred in the form of an ethylenediaminetetraacetic acid (EDTA) complex. The leaching fraction (F) was adjusted so that the concentration of Co-60 at Well 842 matches the observed data. The adjusted value is $1.61\text{E-}5$ and it results in a Co-60 concentration of 267.2 pCi/L observed at the well. Based on the average life of 20 years for a 55-gal steel drum, the F is kept constant for 20-years. After that, F is increased linearly to 1 in the next 110 yr period to reflect a reasonable worst-case scenario. The same functional relationship of F and time is assumed to hold for all radionuclides except H-3. The basis for this assumption is that calibration data are available only for three radionuclides, as mentioned earlier, and no documented evidence of K_d of Cs-137 and Sr-90 being close to 1.2 mL/g in presence of ligands is available. The F was calibrated for H-3 to a value of 0.00172 and is kept constant throughout the simulation period because it is two orders of magnitude higher than that of Co-60.

The simulation results for Area B at 130 years are presented in Table 6-5 for two receptors, one at Well 842 and another at the piezometer Well 650 approximately 19 m from the hypothetical source. The simulation includes the leaching of radionuclides by percolating rainwater through the auger holes, vertical transport of the radionuclides through the 1-ft vadose zone, and a downgradient transport through the shallow saturated zone to the receptors. In addition to Co-60 and H-3, Sr-90 also shows up at the wells in 130 yr.

6.5 CONCLUSIONS

Because of a lack of calibration data, no definitive concentrations can be predicted in Area A for the 130-yr

TABLE 6-5
RESULTS OF THE MODEL SIMULATIONS,
130 YEARS AFTER 1980

Nuclide	Distance to Exposure Point Location	Concentration in Shallow Sat. Zone (pCi/L)
AREA B		
Co-60	68.6 (well 842)	1.52
Co-60	19.0 (well 650)	3.35
Sr-90	68.6 (well 842)	0.0
Sr-90	19.0 (well 650)	848,100
H-3	68.6 (well 842)	595,700
H-3	19.0 (well 650)	1.31E6

receptor. The calibration information in Area B cannot be used in Area A because there is no evidence of solvent auger holes in Area A.

In Area B, Co-60 concentrations at Well 842 can be duplicated by the model by assuming high mobility of Co-60 in the presence of complexing ligands. The ligands are introduced in the system from the solvent auger holes. A similar route should explain the presence of Cs-137 and Sr-90 at the well. To confirm this hypothesis, the forms in which Co-60, Sr-90, and Cs-137 appear at Well 842 should be investigated.

Distribution coefficients and leaching fractions are the two parameters which have maximum impact on the travel time and exposure point concentrations, respectively. The effect on the travel time and receptor concentrations of other parameters, (e.g., thickness of the shallow saturated zone, angle of dispersion, etc.) is considerably lower.

7.0 SELECTED WAG 6 BASELINE RISK ASSESSMENT COMPONENTS, IDENTIFICATION OF ARARS AND CORRECTIVE ACTION OBJECTIVES

Section 7.0 is divided into three major sections. Section 7.1 presents components of the baseline risk assessment which are currently underway at WAG 6. The baseline risk assessment will include an iterative evaluation of risk to human health and the environment in the absence of remedial action (i.e., "no action" alternative). The environmental portion of the baseline risk assessment conducted for WAG 6 will be in the RFI Report and is not included in this report. A WAG-wide environmental evaluation will also be done at a later date. The human health portion of the baseline risk assessment for WAG 6 is currently underway but has not been completed at this time because all the necessary data are not available. As previously discussed in Section 1.0, all the data (including background data) have not been validated, and data from other ORNL sampling programs have not yet been obtained for use in the baseline risk assessment. As the assessment progresses, additional information will be identified and incorporated to improve the accuracy of the process and conservatism of the results. The assessment will be completed and presented in the RFI Report.

In Section 7.2, "Applicable or Relevant and Appropriate Requirements and Other To-Be-Considered Criteria, Advisories and Guidance," ARARs and TBCs are identified for radionuclide and chemical contaminants of potential concern at WAG 6. In Section 7.3, "Preliminary identification of Objectives for Site Closure and Corrective Action," site closure and corrective action objectives are identified for WAG 6.

7.1 SUMMARY OF SELECTED COMPONENTS OF THE BASELINE RISK ASSESSMENT AT WAG 6

The baseline risk assessment requires an understanding of the nature of contaminant releases from the site, the pathways of human exposure, and a measure of the potential risk to human

health as a result of the releases. The assessment includes: 1) data collection and evaluation, 2) exposure assessment (including an exposure pathway analysis for media-specific pathways), 3) toxicity assessment, and 4) risk characterization.

The baseline risk assessment at WAG 6 will be conducted using the methodology presented in EPA's Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A) (U.S. EPA, 1989a). As explained above, the assessment has not been completed for WAG 6. In this section, the components of the assessment which are currently underway will be presented. These include data collection and evaluation of available data and the exposure pathway analysis. The toxicity assessment, exposure assessment (i.e., estimation of intake/dose), and risk characterization portions of the baseline risk assessment have not been completed. These will be completed and presented in the RFI Report.

7.1.1 Data Collection and Evaluation

For the baseline risk assessment at WAG 6, site data was collected and analyzed. Data from the Phase 1 RFI sampling and the ORNL groundwater program were reviewed using the procedures presented in Technical Memorandums 06-01, "RI/FS Data Quality Review," and 06-07, "Validation of ORNL Groundwater Data," respectively. The results of the Phase 1 RFI activities indicated 19 radionuclides and 65 chemicals, measured at concentrations greater than the detection limit, to be of potential concern at WAG 6. The environmental media sampled included surface water, groundwater, and soil. Radionuclides and chemicals measured in each medium are summarized in Tables 7-1 and 7-2, respectively. Naturally occurring isotopes and chemicals are noted in the tables.

The list of radionuclides and chemicals will be re-evaluated, and modified, once background and additional site data become

TABLE 7-1

LIST OF RADIONUCLIDES OF POTENTIAL CONCERN
IN ENVIRONMENTAL MEDIA AT WAG 6

CAS Number	Isotope	Surface Water	Groundwater	Soil
14596-10-2	Americium-241	X	X	
10045-97-3	Cesium-137	X	X	X
10198-40-0	Cobalt-60	X	X	X
13981-16-3	Plutonium-238	X		
0-013	Plutonium-239/240	X		
13966-00-2	Potassium-40		X(a)	X(a)
13233-32-4	Radium-224		X(a)	X(a)
13982-63-3	Radium-226			X(a)
15262-20-1	Radium-228		X(a)	X(a)
(b)	Radium (Total)		X(a)	
10098-97-2	Strontium-90	X	X	X
14274-82-9	Thorium-228	X(a)	X(a)	X(a)
14269-63-7	Thorium-230	X(a)	X(a)	X(a)
7440-29-1	Thorium-232	X(a)	X(a)	X(a)
15065-10-8	Thorium-234			X(a)
10028-17-8	Tritium	X	X	
13966-29-5	Uranium-234	X(a)	X(a)	X(a)
15117-96-1	Uranium-235	X(a)		
7440-61-1	Uranium-238	X(a)	X(a)	X(a)

(a) Denotes a naturally occurring isotope.

(b) No CAS number available.

TABLE 7-2

LIST OF CHEMICALS OF POTENTIAL CONCERN
IN ENVIRONMENTAL MEDIA AT WAG 6

CAS Number	Compound	Surface Water	Groundwater	Soil
71-55-6	1,1,1-Trichloroethane		X	
79-34-5	1,1,2,2-Tetrachloroethane	X	X	
79-00-5	1,1,2-Trichloroethane		X	
75-34-3	1,1-Dichloroethane	X	X	
75-35-4	1,1-Dichloroethene	X	X	
107-06-2	1,2-Dichloroethane	X	X	
540-59-0	1,2-Dichloroethene (total)	X	X	X
78-93-3	2-Butanone	X		X
591-78-6	2-Hexanone			X
108-10-1	4-methyl-2-pentanone	X		
67-64-1	Acetone	X	X	X
71-43-2	Benzene	X	X	
75-15-0	Carbon disulfide	X		X
56-23-5	Carbon tetrachloride		X	
108-90-7	Chlorobenzene	X		X
75-00-3	Chloroethane		X	
67-66-3	Chloroform		X	X
100-41-4	Ethyl benzene		X	X
75-09-2	Methylene chloride			X
127-18-4	Tetrachloroethene	X	X	X
108-88-3	Toluene	X	X	X
79-01-6	Trichloroethene	X	X	X
108-05-4	Vinyl acetate	X		
75-01-4	Vinyl chloride		X	
1330-20-7	Xylenes (total)		X	X
95-48-7	2-Methylphenol		X	
65-85-0	Benzoic acid			X
56-55-3	Benzo(a)anthracene			X
50-32-8	Benzo(a)pyrene			X
205-99-9	Benzo(b)fluoranthene			X
207-08-9	Benzo(k)fluoranthene			X
100-51-6	Benzyl alcohol			X
117-81-7	bis(2-ethylhexyl)phthalate	X	X	X
218-01-9	Chrysene			X
84-66-2	Diethylphthalate		X	X
84-74-2	Di-n-butylphthalate	X	X	X
117-84-0	Di-n-octylphthalate			X
91-20-3	Napthalene	X	X	X
86-30-6	N-nitrosodiphenylamine			X
108-95-2	Phenol			X
11097-69-1	Aroclor 1254		X	
7429-90-5	Aluminum(a)	X	X	X
7440-36-0	Antimony	X	X	X
7440-38-2	Arsenic	X	X	X
7440-39-3	Barium	X	X	X

TABLE 7-2 (Continued)

CAS Number	Compound	Surface Water	Groundwater	Soil
7440-41-7	Beryllium	X	X	X
7440-43-9	Cadmium	X	X	X
7440-70-2	Calcium	X	X	X
7440-47-3	Chromium VI	X	X	X
7440-48-4	Cobalt	X	X	X
7440-50-8	Copper	X	X	X
57-12-5	Cyanide			X
7439-89-6	Iron	X	X	X
7439-92-1	Lead	X	X	X
7439-95-4	Magnesium	X	X	X
7439-96-5	Manganese	X	X	X
7439-97-6	Mercury	X	X	X
7440-02-0	Nickel	X	X	X
7440-09-7	Potassium	X	X	X
7782-49-2	Selenium	X	X	X
7440-22-4	Silver	X	X	X
7440-23-5	Sodium	X	X	X
7440-28-0	Thallium			X
7440-62-2	Vanadium	X	X	X
7440-66-6	Zinc	X	X	X

(a) All metals are naturally occurring. Comparison with background data has not been completed, concentrations may or may not be substantially above background values.

available. Background samples have been collected but have not gone through data quality review and therefore cannot be used in the risk assessment at this time. Background values will be assessed and used as a basis of comparison against measured values to identify possible naturally occurring concentrations of compounds or non-site-related contaminants that are found at or near the site.

In addition to the above analysis, tentatively identified compounds (TICs) and transformation products of chemicals and radionuclides will be evaluated and addressed in the data evaluation component of the baseline risk assessment.

7.1.2 Exposure Pathway Analysis

The exposure pathway analysis includes identification of institutional control time periods, and exposure points, receptors, and exposure routes relevant to WAG 6. The potential pathways by which human receptors may be exposed to contaminants at WAG 6 are addressed based on current and possible future land use of the site.

Exposure pathways for WAG 6 are assessed relative to three institutional control time periods. For the time periods greater than 130 years, two receptor scenarios are presented as illustrated in Figure 7-1. Receptor time periods considered for the WAG 6 site are presented below:

- o Controlled (Operational) Period, 0-30 Years: ORNL remains operational for the next 30 years. No public access is permitted on the ORNL facility (including WAG 6). The no public access policy is currently in effect.
- o Controlled (Post-Operational) Period, >30-130 Years: DOE will maintain control of the ORNL facility for a 100 year post-operational period. No public access will be permitted on the ORNL facility (including WAG 6). The no public access policy is currently in effect.

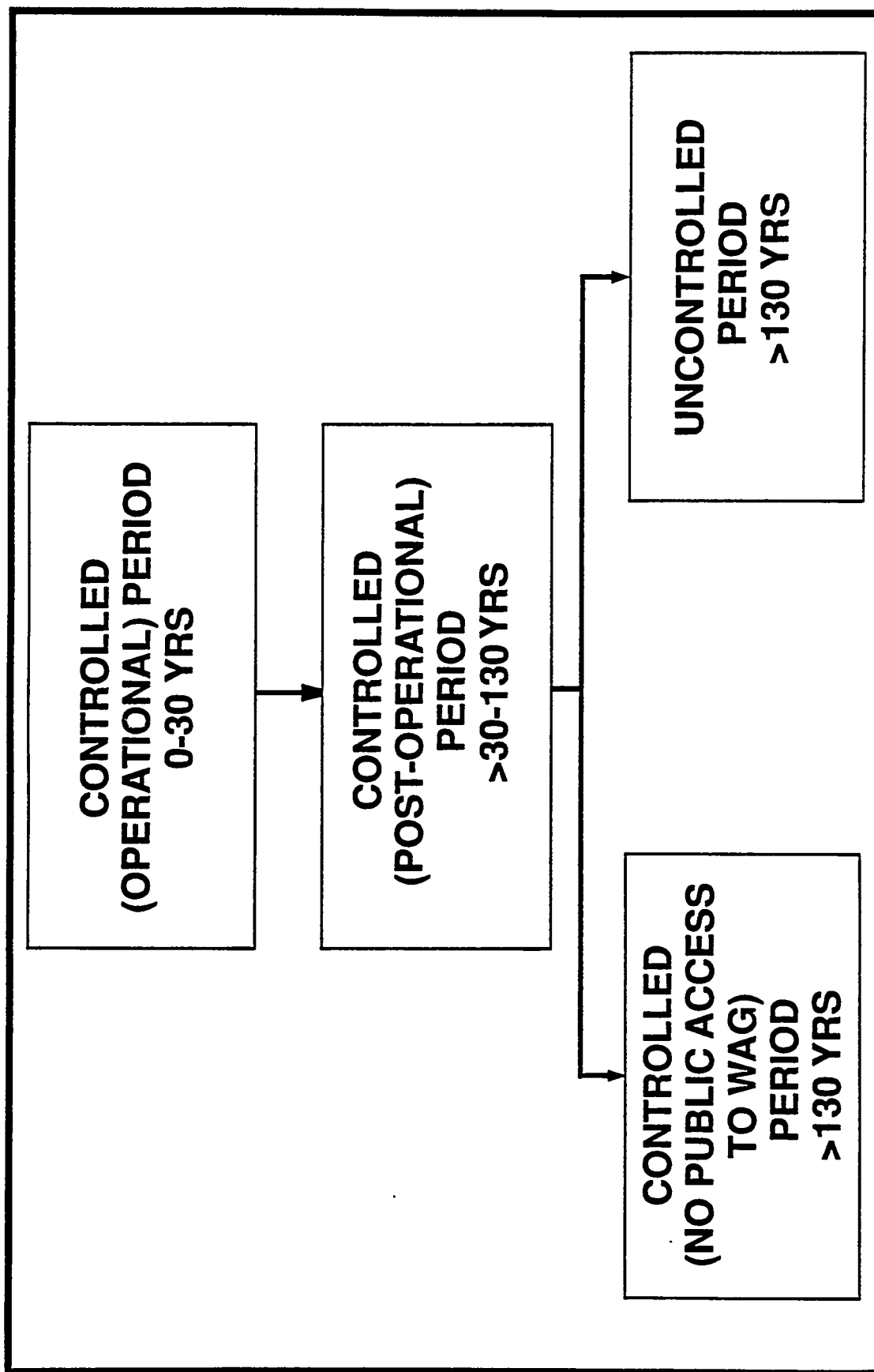


FIGURE 7-1
WAG 6 INSTITUTIONAL TIME PERIODS

- o Greater than 130 Years: Controlled (No Public Access to WAG) Period--DOE will maintain control of the ORNL facility (including WAG 6) for an indefinite period of time. Maintenance and surveillance activities by ORNL employees will continue indefinitely. No public access will be allowed on WAG 6.
- o Uncontrolled Period--DOE will have no control over the ORNL facility or WAG 6. ORNL facility property (including WAG 6) will be available for unrestricted uses (i.e., residential, agricultural uses).

For the WAG 6 area during the controlled periods, potential exposure points (i.e., any point(s) where potential contact with a contaminated medium is possible) and receptors are identified relative to location on the ORR, ORNL, and WAG 6 during the institutional control periods. The ORR is that area owned by the federal government and includes the ORNL facility, the Y-12 Weapons Plant, and the ORGDP. The ORNL facility is delineated by the environmental, safety and health buffer zone for the facility. During the controlled periods, ORNL will be regarded as an area that is not permanently occupied but may be multiple use property (i.e., it may be shared for such uses as agriculture, forest management, and research) (Chance, 1986). These boundaries are shown in Figure 7-2. During the uncontrolled period, no WAG 6, ORNL, or ORR distinctions exist. However, all exposure scenarios during this period will be in the area where WAG 6 wastes are located.

The WAG 6 receptor exposure points consist of areas on and off WAG 6. Off-wag receptors are identified as those at the WAG boundary, and within a one-half mile, a one-mile, and a three-mile radius from the WAG boundary. All of the off-WAG receptors will be addressed in the WAG 6 risk assessment. However, the evaluation of off-WAG receptors may take place at different times in the RI/FS process for the ORR. If there are receptors identified within other WAGs, then they will be assessed in that WAG's risk assessment. The off-ORR receptor will also be addressed in an off-reservation risk assessment.

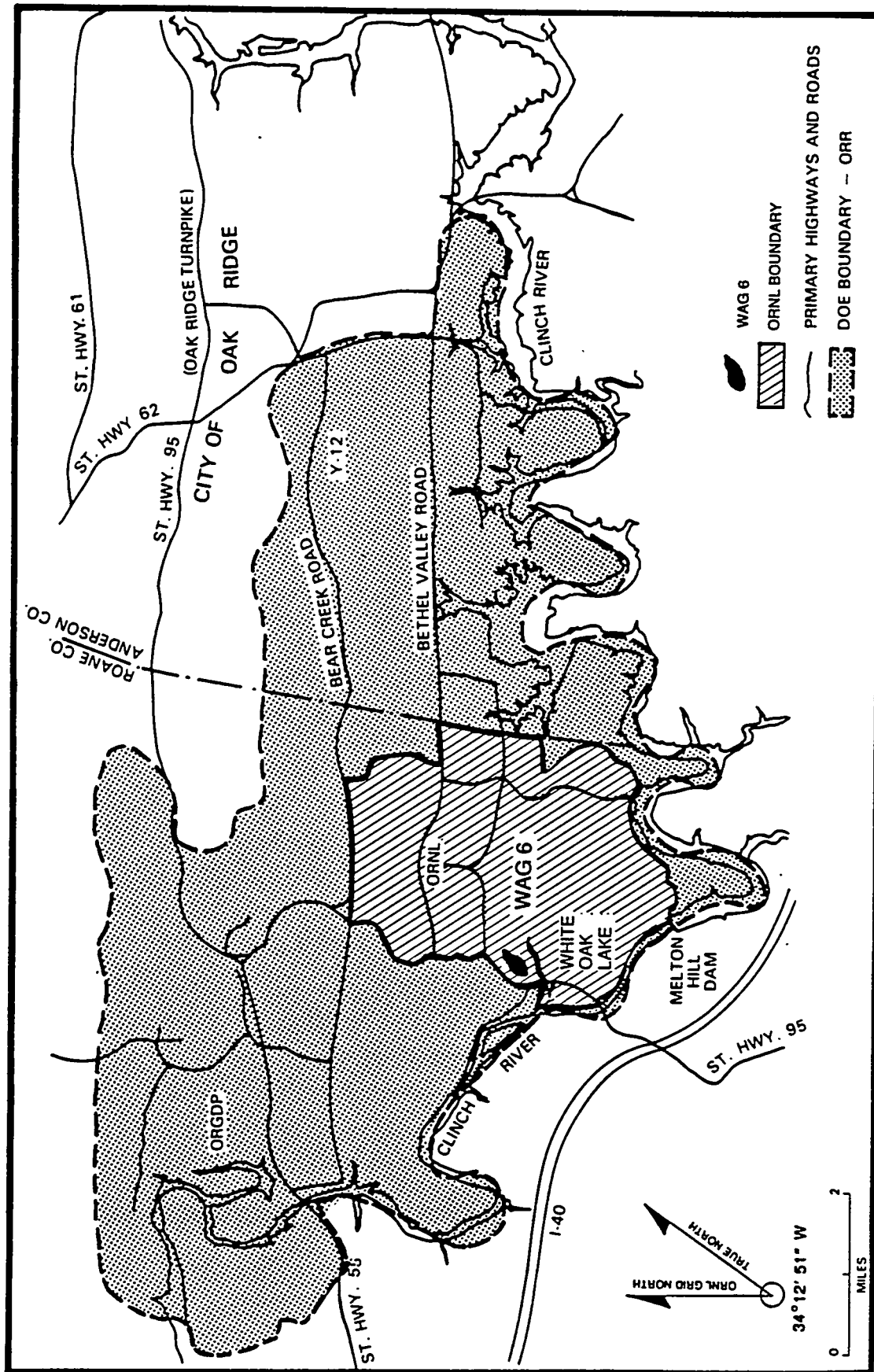


FIGURE 7-2
BOUNDARIES WITHIN THE OAK RIDGE RESERVATION
DURING THE CONTROLLED PERIODS

A reasonable maximum exposure scenario (U.S. EPA, 1988e) will be identified and a risk determination will be conducted for those receptors at exposure points on WAG 6 and at the WAG boundary during the controlled and uncontrolled institutional periods. The reasonable maximum scenario will be developed so that the combination of exposure parameters for an individual are those that are most likely to occur to an actual receptor (U.S. EPA, 1988e).

As more data become available from the site, specific on-WAG and boundary receptor points will be identified. Currently, two receptor groups for WAG 6 are described in a general way relative to institutional time periods and proximity to identified disposal areas: the receptor on WAG 6, and the receptor at the WAG 6 boundary.

During the controlled periods on WAG 6, it is assumed that receptors on the waste disposal areas are ORNL non-radiation protection workers and that they are required to wear appropriate protective clothing (e.g., maintenance and surveillance workers). During the uncontrolled period, no restrictions are placed on receptors on the disposal areas. Potential receptors during the uncontrolled period include intruders into the waste (e.g., constructing a house in a contaminated area on the WAG; installing a well for drinking water purposes in a contaminated area; ingesting crops grown in a garden with contaminated soil and irrigated with contaminated water).

During the controlled periods, activities for receptors at the WAG boundary include casual, non-invasive uses. During the uncontrolled period, no restrictions are placed on receptors at the WAG boundary (i.e., intrusion into migrated waste is possible).

Once an exposure point and potential receptor(s) are identified, possible exposure route(s) must also be identified. An exposure

route is the way a contaminant or physical agent comes in contact with a receptor. Possible exposure routes considered for WAG 6 receptors at exposure points during the controlled and uncontrolled institutional periods include:

- o For chemicals - ingestion, incidental ingestion, inhalation, and dermal contact
- o For radionuclides - ingestion, incidental ingestion, inhalation, immersion in air, and exposure to ionizing radiation

Incidental ingestion refers to ingestion of a medium for nonnutritive purposes (e.g., ingestion of soil by children while playing).

A summary of all the potentially complete exposure pathways for on-WAG 6 and WAG 6 boundary receptors is presented in Figure 7-3. This figure summarizes for each potential exposure pathway the exposure pathway elements relevant to WAG 6. Pathway elements include: a source of contamination, a release mechanism, a transport medium, an exposure point (relative to potential receptors), and an exposure route.

7.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER TO-BE-CONSIDERED CRITERIA, ADVISORIES, AND GUIDANCE

Section 121 of CERCLA requires that, subject to specified exceptions, remedial actions must be in compliance with ARARs and TBCs. ARARs and TBCs are identified at several steps in the remedy selection process. Section XXI(F) of the Federal Facilities Agreement (FFA) for the environmental restoration of the ORR calls for the preparation of a draft listing of all ARARs as mandated by §121 of SARA. Pursuant to this requirement, a draft report (Etnier and Weaver, 1990) summarizing potential ARARs and TBC guidance has been submitted under separate cover for review and approval by EPA and TDHE. A summary of the contents of this ARAR report for chemicals and radionuclides is

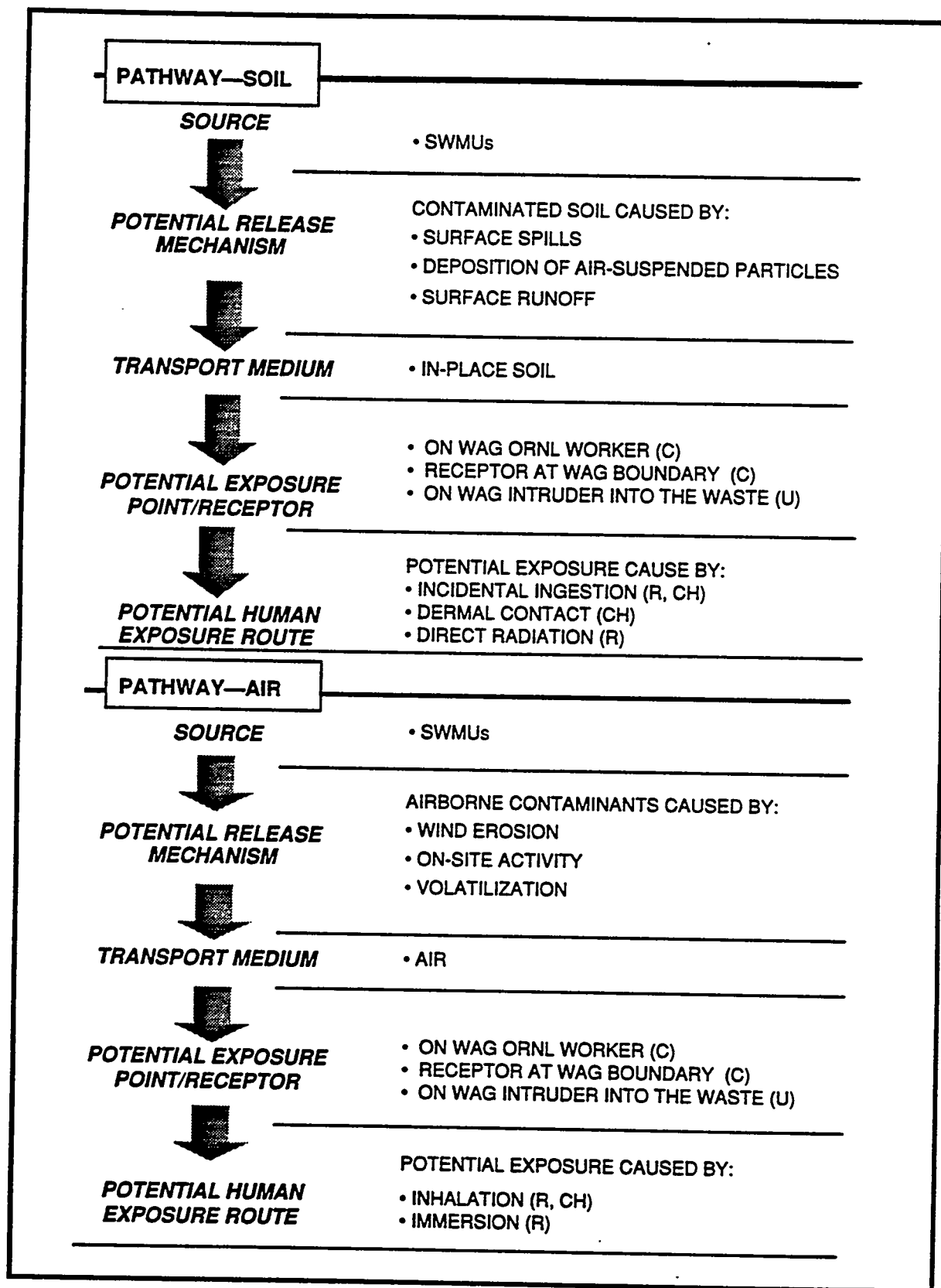


FIGURE 7-3
PRELIMINARY HUMAN EXPOSURE PATHWAYS

PATHWAY—GROUNDWATER

SOURCE



- SWMUs

**POTENTIAL RELEASE
MECHANISM**



- CONTAMINATED GROUNDWATER CAUSED BY:
- CONTACT WITH CONTAMINATED SOIL
 - CONTACT WITH WASTE

TRANSPORT MEDIUM



- GROUNDWATER

**POTENTIAL EXPOSURE
POINT/RECEPTOR**



- ON WAG INTRUDER INTO THE WASTE (U)

**POTENTIAL HUMAN
EXPOSURE ROUTE**

- POTENTIAL EXPOSURE CAUSED BY:
- INGESTION (R, CH)

PATHWAY—SURFACE WATER

SOURCE



- SWMUs

**POTENTIAL RELEASE
MECHANISM**



- CONTAMINATED SURFACE WATER CAUSED BY:
- CONTAMINATED SOIL CONTACT
 - GROUNDWATER DISCHARGE
 - CONTAMINATED TRENCH WATER IN
BATH TUBBING TRENCHES

TRANSPORT MEDIUM



- SURFACE WATER

**POTENTIAL EXPOSURE
POINT/RECEPTOR**



- ON WAG INTRUDER INTO THE WASTE (U)

**POTENTIAL HUMAN
EXPOSURE ROUTE**

- POTENTIAL EXPOSURE CAUSED BY:
- INCIDENTAL INGESTION (R, CH)
 - DERMAL CONTACT (CH)

FIGURE 7-3 (Continued)

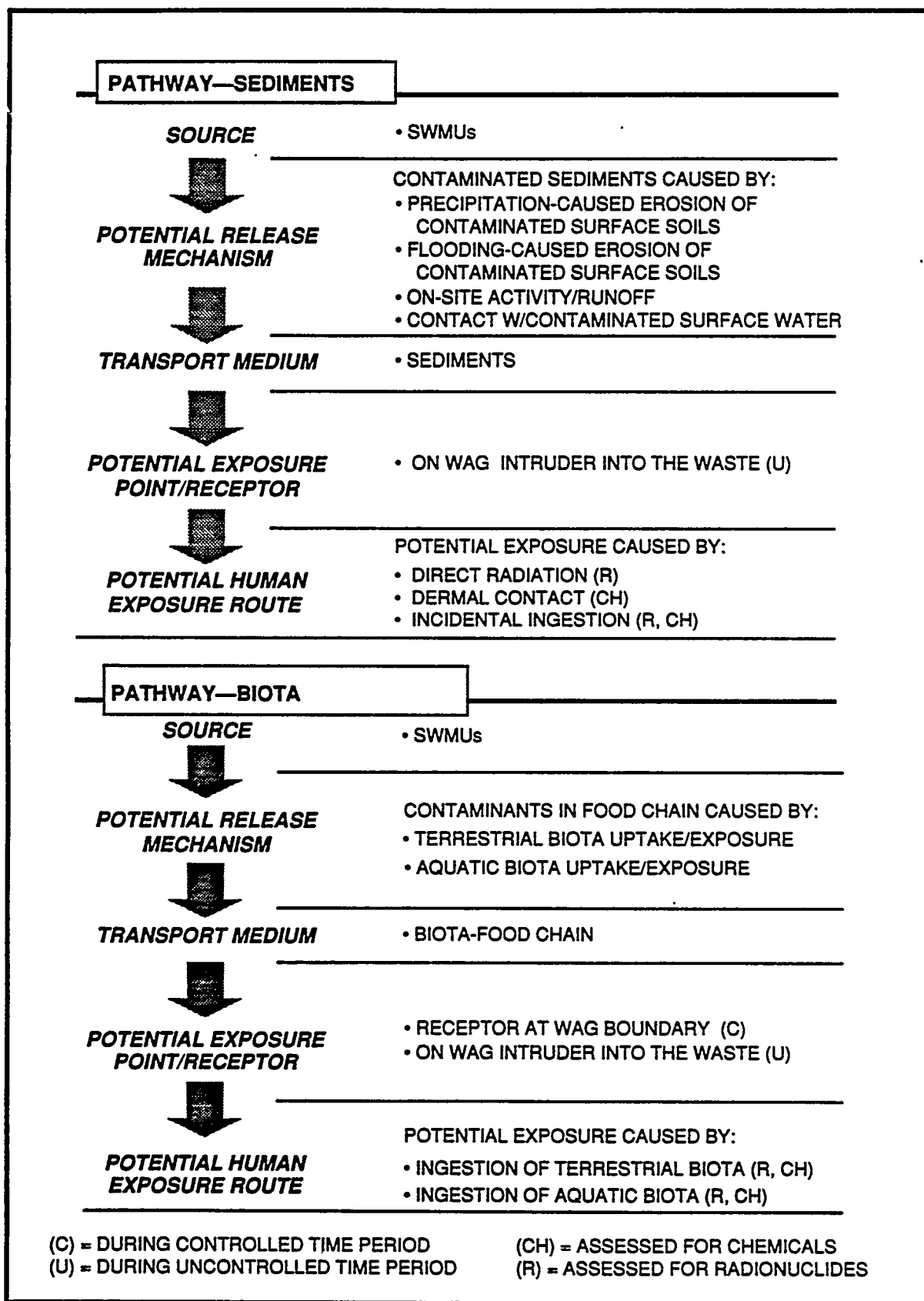


FIGURE 7-3 (Continued)

included in this section for completeness. Additionally, health-based criteria consisting of ARARs and TBCs (including values calculated from TBCs) were identified to give a preliminary indication where contamination may be a threat to human health. Note that these calculated health-based criteria do not represent cleanup goals. As additional information is developed about the site, more ARARs and TBCs may be identified, and the list of "potential" ARARs and TBCs will be further refined. During the development of remedial alternatives in the feasibility study, action-specific ARARs will be identified and evaluated for each proposed alternative.

7.2.1 Chemical-Specific ARARs and TBCs

From the evaluation of site-specific information, chemical-specific ARARs and TBCs have been identified for the WAG 6 chemicals of potential concern presented in Section 7.1.1. However, these chemicals have not been compared to their background concentrations. When the data for background samples are available, the chemicals of potential concern will be adjusted accordingly.

ARARs and TBCs were identified for the WAG 6 chemicals of potential concern by following the CERCLA Compliance With Other Laws Manual (U.S. EPA, 1988). The following chemical-specific standards were evaluated as ARARs and TBCs:

ARARs

- o Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) (Includes the RCRA Maximum Concentration Limits) (U.S. EPA, 1989b; U.S. EPA, 1989e)
- o Safe Drinking Water Act (SDWA) Maximum Contaminant Level Goals (MCLGs) (Includes the RCRA Maximum Concentration Limits) (U.S. EPA, 1989b; U.S. EPA, 1989e)
- o Federal Water Quality Criteria (WQC) (U.S. EPA, 1987a)
- o Tennessee Secondary Drinking Water Standards (TDHE, 1988)

TBCs

- o Safe Drinking Water Act (SDWA) Secondary Maximum Contaminant Levels (EPA, 1987)
- o EPA Drinking Water Health Advisories (U.S. EPA, 1988c)
- o Reference Doses (U.S. EPA, 1989c; U.S. EPA, 1989d)
- o Slope Factors or Carcinogen Potency Factors (U.S. EPA, 1989c; U.S. EPA, 1989d)

Making the assumption that the groundwater in WAG 6 would be classified as IIB (i.e., potential source of drinking water), the following discussion identifies groundwater-specific ARARs, TBCs, and other health-based criteria. For each of the chemicals of potential concern, a SDWA MCL was used if available. The rules of the TDHE lists MCLs for public water systems and secondary MCLs for domestic water supplies that are identical to the federal MCLs and therefore are not repeated in this document. If no federal MCLs were available, secondary MCLs, proposed MCLs and federal WQC were evaluated as an ARAR or TBC. In many cases, the proposed MCL was the same value as the drinking water health advisory. If proposed MCLs were available, they were listed along with another TBC because they are not, as yet, promulgated. Based on new toxicological values, the EPA Office of Criteria and Standards is currently revising federal WQC for over 40 chemicals. When revised, these criteria will be relevant and appropriate, will be submitted to EPA and TDHE for approval, and will be incorporated into the RFI Report. In place of the existing federal WQC, updated EPA chemical-specific health-based values (e.g., reference doses) were used to calculate health-based criteria. For several chemicals that had no ARARs, health advisories, slope factors, or reference doses were listed.

Health-based criteria were calculated from reference doses and slope factors using a conservative approach. If both a reference dose and slope factor were available for a chemical, the resulting health-based criterion that was more conservative

(i.e., greater risk) was listed. Health-based criterion were calculated using the approach specified in the Interim Final RCRA Facility Investigation (RFI) Guidance (U.S.EPA, 1989f).

There are currently no directly usable ARARs and TBCs for soil ingestion. Therefore, health-based criteria were calculated for soil ingestion for those chemicals of potential concern that had a reference dose or carcinogen potency factor. The approach utilized the guidance document stated above (U.S EPA, 1989f).

Tables 7-3 and 7-4 list the ARARs and TBCs for chemicals of potential concern at WAG 6 for groundwater and soils (contingent on approval by EPA/TDHE), respectively. Health-based criteria, calculated from TBCs and included in Tables 7-3 and 7-4, were developed to give a preliminary indication where contamination may be a threat to human health.

ARARs and TBCs are currently being developed for both air and surface water pathways. Currently, the Clean Air Act National Ambient Air Quality Standards (40 CFR 50) are identified as an ARAR. The surface water at WAG 6 is seasonal (Section 4.4) and is not sufficient to be considered as a drinking water source. ARARs and TBCs for surface water are currently being investigated. Fresh water quality criteria for protection of fresh water organisms have not been included in this report. However, these criteria will be evaluated and, if appropriate, incorporated into the RFI Report.

Other sources are being investigated for those chemicals that do not have an ARAR or TBC from the above listed sources. If an ARAR or TBC is still not identified after this search, then EPA's Environmental Criteria and Assessment Office (ECAO) will be contacted for information. In addition, as ARARs and TBCs are updated, the revised values will be included in this report.

TABLE 7-3
WATER ARARs, TBCs, AND HEALTH BASED CRITERIA FOR CHEMICALS
OF POTENTIAL CONCERN AT WAG 6

CAS Number	Compound	ARAR, TBC, Health Based Criteria (mg/L)	Reference ^(a)
VOLATILES			
75-01-4	Vinyl chloride	0.002	MCL
75-00-3	Chloroethane	Data Inadequate	
67-64-1	Acetone	3.5	RfD - IRIS
75-15-0	Carbon disulfide	3.5	RfD - IRIS
75-35-4	1,1-Dichloroethene	0.007	MCL
75-34-3	1,1-Dichloroethane	0.00038	SF-HEA (CLASS B2)
540-59-0	1,2-Dichloroethene (Total)	No data	
156-59-2	1,2-Dichloroethene (Cis)	0.07	P MCL
156-60-5	1,2-Dichloroethene (Trans)	.1	P MCL & DW HA
067-66-3	Chloroform	0.0057	SF - IRIS(c)
107-06-2	1,2-Dichloroethane	0.005	MCL
78-93-3	2-Butanone	1.8	RfD - IRIS
71-55-6	1,1,1-Trichloroethane	0.2	MCL
56-23-5	Carbon tetrachloride	0.005	MCL
108-05-4	Vinyl acetate	No data	
79-01-6	Trichloroethene	0.005	MCL
79-00-5	1,1,2-Trichloroethane	0.0061(c)	SF - IRIS (CLASS C)(c)
71-43-2	Benzene	0.005	MCL
108-10-1	4-Methyl-2-pentanone	1.8	RfD - IRIS
127-18-4	Tetrachloroethene	0.005/.00069	P MCL/SF - HEA (CLASS B2)(c)
108-88-3	Toluene	2./04	P MCL & DW HA/P SMCL
79-34-5	1,1,2,2-Tetrachloroethane	0.0018	SF - IRIS (CLASS C)(c)
108-90-7	Chlorobenzene	0.1	P MCL & DW HA
100-41-4	Ethyl Benzene	3.5	RfD - IRIS(b)
1330-20-7	Xylenes (Total)	10./02	P MCL & DW HA/P SMCL
SEMI-VOLATILES			
95-48-7	2-Methyphenol	1.8	RfD - IRIS
91-20-3	Naphthalene	14.	RfD - HEA
84-66-2	Diethylphthalate	28.	RfD - IRIS(c)
84-74-2	Di-n-butylphthalate	3.5	RfD - IRIS
117-81-7	bis(2-Ethylhexyl)phthalate	0.0025	SF - IRIS (CLASS B2)
PESTICIDES			
11097-69-1	Aroclor 1254	0.0005/4.5E-6	PMCL/SF-IRIS (CLASS B2)(c)
ANALYTES			
7429-90-5	Aluminum	0.05	DW HA
7440-36-0	Antimony	0.014	RfD - IRIS(b)
7440-38-2	Arsenic	0.05	MCL
7440-39-3	Barium	1.0/5.	MCL/P MCL & DW HA
7440-41-7	Beryllium	8.14e-6	SF - IRIS (CLASS B2)(c)
7440-43-0	Cadmium	0.01/.005	MCL/P MCL & DW HA
7440-70-2	Calcium	No data	
7440-47-3	Chromium VI(total)	0.175	RfD - IRIS
7440-48-4	Cobalt	Data inadequate	
7440-50-8	Copper	1.3	P MCL & DW - HA
7430-89-6	Iron	0.3	T SMCL
7439-92-1	Lead	0.05/.005	MCL/P MCL
7439-95-4	Magnesium	No data	
7439-96-5	Manganese	0.05	T SMCL
7439-97-6	Mercury	0.002	MCL

TABLE 7-3 (Continued)

CAS Number	Compound	ARAR or TBC (mg/L)	Reference ^(a)
7440-02-2	Nickel	0.2	DW HA
7440-09-7	Potassium	No data	
7782-49-2	Selenium	0.01/.05	MCL/P MCL & DW HA
7440-22-4	Silver	0.05	MCL
7440-23-5	Sodium	No data	
7440-62-2	Vanadium	0.245	RfD - HEA
7440-66-6	Zinc	5.0	T SMCL
OTHER (M Fibers/L)			
1332-21-4	ASBESTOS(fiber > 10 μ m)	0.007	P MCL

(a) References include the following:

- MCL = Safe Drinking Water Act Maximum Contaminant Level (MCL) (U.S. EPA, 1989b)
- P MCL = Proposed Safe Drinking Water Act MCL (U.S. EPA, 1989e)
- T SMCL = Tennessee Secondary Drinking Water Standard (TDHE, 1988)
- DW HA = EPA Drinking Water Health Advisories (U.S. EPA, 1988c)
- RfD = Calculated from the Reference Dose using a 70-kg adult and 2 L/d (U.S. EPA, 1989f)
- IRIS = Integrated Risk Information System (IRIS) Chemical Files (U.S. EPA, 1989c)
- HEA = Health Effects Assessment Summary Tables (HEA) (U.S. EPA, 1989d)
- SF = Calculated from Carcinogen Potency Factor or Slope Factor using the specified risk level of 1e-6 for Class A and B carcinogens, and 1e-5 for Class C carcinogen, a 70-kg adult ingesting 2 L/d (U.S. EPA, 1989f)

(b) Slope factor or reference dose was used instead of water quality criteria value, a chemical for which water quality criteria will be updated in Spring 1990.

(c) Slope factor or reference dose was used instead of water quality criteria value.

TABLE 7-4
SOIL TBCs/HEALTH BASED CRITERIA FOR CHEMICALS
OF POTENTIAL CONCERN AT WAG 6

CAS Number	Compound	TBC/Health Based Criteria (mg/kg)	Reference ^(a)
VOLATILES			
75-09-2	Methylene Chloride	9.3e+01	SF - IRIS (CLASS B2)
67-64-1	Acetone	8.0e+03	Rfd - IRIS
75-15-0	Carbon Disulfide	8.0e+03	Rfd - IRIS
540-59-0	1,2-Dichloroethene (Total)	No data	
67-66-3	Chloroform	1.1e+02	SF - IRIS (CLASS B2)
78-93-3	2-Butanone	4.0e+03	Rfd - IRIS
79-01-6	Trichloroethene	6.4e+01	SF - HEA (CLASS B2)
591-78-6	2-Hexanone	No data	
127-18-4	Tetrachloroethene	1.4e+01	SF - HEA (CLASS B2)
108-88-3	Toluene	2.4e+04	Rfd - IRIS
108-90-7	Chlorobenzene	1.6e+03	Rfd - IRIS
100-41-4	Ethyl Benzene	8.0e+03	Rfd - IRIS
1330-20-7	Xylenes (Total)	1.6e+05	Rfd - IRIS
SEMI-VOLATILES (mg/kg)			
108-95-2	Phenol	4.8e+04	Rfd - IRIS
100-51-6	Benzyl alcohol	2.4e+04	Rfd - HEA
65-85-0	Benzoic acid	3.2e+05	Rfd - IRIS
91-20-3	Naphthalene	3.2e+04	Rfd - HEA
84-66-2	Diethylphthalate	6.4e+04	Rfd - IRIS
86-30-6	N-nitrosodiphenylamine	1.4e+02	SF - IRIS
84-74-2	Di-n-butylphthalate	8.0e+03	Rfd - HEA
56-55-3	Benzo(a)anthracene	6.1e-02(b)	SF - IRIS (CLASS B2)
218-01-9	Chrysene	6.1e-02(b)	SF - IRIS (CLASS B2)
117-81-7	bis(2-Ethylhexyl)phthalate	5.0e+01	SF - IRIS (CLASS B2)
117-84-0	Di-n-octylphthalate	Data inadequate	
205-99-2	Benzo(b)fluoranthene	6.1e-02(b)	SF - IRIS (CLASS B2)
207-08-9	Benzo(k)fluoranthene	6.1e-02(b)	SF - IRIS (CLASS B2)
50-32-8	Benzo(a)pyrene	6.1e-02(b)	SF - IRIS (CLASS B2)
ANALYTES (mg/kg)			
7429-90-5	Aluminum	No data	
7440-36-0	Antimony	3.2e+01	Rfd - IRIS
7440-38-2	Arsenic	8.0e+01	Rfd - HEA
7440-39-3	Barium	4.0e+03	Rfd - IRIS
7440-41-7	Beryllium	1.6e-01	SF - IRIS (CLASS B2)
7440-43-9	Cadmium	4.0e+01	Rfd - IRIS
7440-70-2	Calcium	No data	
7440-47-3	Chromium VI	4.0e+02	Rfd - IRIS
7440-48-4	Cobalt	Data inadequate	
7440-50-9	Copper	No data	
57-12-5	Cyanide	1.6e+03	Rfd - IRIS
7439-89-6	Iron	Data inadequate	
7439-92-1	Lead	Data inadequate	
7439-95-4	Magnesium	No data	
7439-96-5	Manganese	1.6e+04	Rfd - HEA
7439-97-6	Mercury	2.4e+01	Rfd - HEA
7440-02-2	Nickel	1.6e+03	Rfd - IRIS
7440-09-7	Potassium	No data	
7782-49-2	Selenium	2.4e+02	Rfd - IRIS
7440-22-4	Silver	2.4e+02	Rfd - IRIS
7440-23-5	Sodium	No data	
7440-28-0	Thallium	5.6e+00	Rfd - HEA
7440-62-2	Vanadium	5.6e+02	Rfd - HEA
7440-66-6	Zinc	1.6e+04	Rfd - HEA

^(a)References include the following:

Rfd = Calculated from the Reference Dose using a 16 kg child ingesting .2 g/d (U.S. EPA, 1989f)

SF = Calculated from Carcinogen Potency Factor or Slope Factor using the specified risk level of 1e-6 for class A and B carcinogens, and 1e-5 for class C carcinogens, a 70 kg adult ingesting .1 g/d (U.S. EPA, 1989f)

IRIS = Integrated Risk Information System (IRIS) Chemical Files (U.S. EPA, 1989c)

HEA = Health Effects Assessment Summary Tables (U.S. EPA, 1989d)

7.2.2 Radionuclide-Specific ARARs and TBCs

For WAG 6, radionuclide-specific ARARs and TBCs have been identified. They include the following:

ARARs

- o Tennessee Drinking Water Standards Maximum Contaminant Level (TDHE, 1988)
- o Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCL) (U.S. EPA, 1989b)
- o Health and Environmental Protection Standards for Uranium Mill Tailings (U.S. EPA, 1987b)
- o National Emission Standards for Hazardous Air Pollutants (U.S. EPA, 1989g)
- o Environmental Radiation Protection Standards for Nuclear Power Operations (U.S. EPA, 1986c)

TBCs

- o Radionuclide-Specific Slope Factors (available through EPA-ECAO)
- o Licensing Requirements for Land Disposal of Radioactive Waste (U.S. NRC, 1989b)
- o Standards for Protection Against Radiation (U.S. NRC, 1986, U.S. NRC, 1989a)
- o Statement from the 1985 Paris Meeting of the International Commission on Radiological Protection (ICRP) (ICRP, 1985)
- o Recommendations on Limits for Exposure to Ionizing Radiation (NCRP, 1987)
- o DOE Order 5480.1A: Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities (DOE, 1985)
- o DOE Order 5820.2A: Management of Low-Level Waste, Chapter III in Radioactive Waste Management (DOE, 1988)
- o DOE Order 5400.XX: Impending Revisions of DOE Standards: Drinking Water Requirements (DOE, 1989)

The standards and guidance listed above are promulgated or in final form. Currently, other standards, criteria, and guidance

are being reviewed, including those that are proposed (e.g., 40 CFR 193). The ARAR and TBC listing for radionuclides appears in its entirety in the draft ARARs report (Etnier and Weaver, 1990) and will be updated as appropriate. In general, the ARARs and TBCs for radionuclides associated with WAG 6 are listed in Table 7-5.

7.2.3 Location-Specific ARARs

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations (U.S. EPA, 1988). These requirements are utilized to determine the acceptability of a site for waste disposal, treatment, or storage. Selected location-specific ARARs are presented in Table 7-6 contingent on approval by EPA and TDHE. Development of location-specific ARARs is ongoing throughout the baseline risk assessment and alternative assessment process; and therefore, as new location-specific ARARs are developed, they will be added to this table.

7.2.4 Use of ARARs and TBCs

ARARs and TBCs must be attained for hazardous substances remaining on site at the completion of WAG 6 remedial action. Generally, EPA's policy is to attain ARARs and TBCs to ensure protection at all points of potential exposure. For WAG 6, documentation will be provided to support the rationale that a chemical-, radionuclide-, location-, or action-specific requirement is applicable or is relevant and appropriate for WAG 6 for each remedial action alternative that passes through the screening and into detailed analysis. If no potential ARARs

TABLE 7-5

ARARs or TBCs FOR RADIONUCLIDES AT WAG 6

CAS Number	Compound	Scenario	ARAR or TBC	Reference (a)
Off-site individuals from all exposure pathways				
10028-17-8	Tritium	Inadvertent intruders from all exposure pathways (following loss of institutional controls) - For continuous exposure - For acute or occasional exposure	25 mrem/yr 100 mrem/yr 500 mrem/yr	NRC1, DOE1, EPA1, EPA2 DOE1, ICRP, NCRP, NRC2, EPA3
13982-63-3	Radium 226 and Radium 228	Community drinking water system	20,000 pCi/L	SDWA MCL and TENN MCL
15262-20-1	combined	Community drinking water system	5 pCi/L	SDWA MCL, TENN MCL, Mill Tailings
13982-63-3	Radium 226	In land averaged over 100 square meters	5 pCi/g (b) 15 pCi/g (c)	Mill Tailings
10098-97-2	Strontium-90	Community Drinking Water System	8 pCi/L	SDWA MCL and TENN MCL
	Gross alpha particle activity (including Radium-226 but excluding radon and uranium)	Community Drinking Water System	15 pCi/L	SDWA MCL, TENN MCL, Mill Tailings
	Gross beta particle and photon radioactivity	Community Drinking Water System	4 mrem/yr	SDWA MCL, TENN MCL, DOE3

(a) References include the following:

SDWA MCL = Safe Drinking Water Act Maximum Contaminant Level (MCL), (U.S. EPA, 1989b)

TENN MCL = Tennessee Drinking Water Standards MCL (TDHE, 1988)

MILL TAILINGS = Health and Environmental Protection Standards for Uranium Mill Tailings (U.S. EPA, 1987b)

DOE1 = Management of Low-Level Waste (DOE, 1988)

DOE2 = Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities (DOE, 1985)

DOE3 = Impending Revisions of DOE Standards: Drinking Water Requirement (DOE, 1989)

ICRP = Statement from the 1985 Paris Meeting of the International Commission on Radiological Protection (ICRP, 1985)

NCRP = Recommendations on Limits for Exposure to Ionizing Radiation (NCRP (91), 1987)

NRC1 = Licensing Requirements for Land Disposal of Radioactive Waste (NRC, 1989b)

NRC2 = Proposed Revision of Radiation Protection Standards (NRC, 1986)

NRC3 = Standards for Protection Against Radiation: Unrestricted Areas (10 CFR 20, Section 20.105) (1989a) where: whole body acute =

0.5 rem/yr Annual Effective Dose Equivalent whole body continuous = 0.1 rem/yr Annual Effective Dose Equivalent

EPA1 = NESHAPS (U.S. EPA, 1989g) where: 25 mrem/yr (whole body); 75 mrem/yr (critical organ) Annual Effective Dose Equivalent

EPA2 = Radiation Protection Standards: (U.S. EPA, 1989g) where: 25 mrem/yr (whole body); 75 mrem/yr (thyroid); 25 mrem/yr (critical

organs) Annual Effective Dose Equivalent

EPA3 = NESHAPS (U.S. EPA, 1989g) where: 0.1 rem/yr whole body continuous exposure; 0.5 rem/yr whole body acute exposure Annual

Effective Dose Equivalent

(b) Averaged over first 15 cm below surface.

(c) Averaged over 15-cm thick layers more than 15 cm below the surface.

TABLE 7-6

LOCATION-SPECIFIC ARARS or TBCs(a)

Location	Requirement	Prerequisite for Applicability	Citation
Within 100-year floodplain	Facility must be designed, constructed, operated, and maintained to avoid washout	RCRA hazardous waste; treatment, storage, or disposal	40 CFR 264.18(b) 40 CFR 270.1(b)(11) and (iv)
Within floodplain(b)	Action to avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values	Action that will occur in a floodplain (i.e., lowlands and relatively flat areas adjoining inland and coastal waters and other flood-prone areas)	Protection of floodplain(b) (40 CFR 6, Appendix A); Fish and Wildlife Coordination Act (16 USC 661 <u>et seq.</u>); 40 CFR 6.302
Within salt dome formation, underground mine, or cave	Placement of non-containerized or bulk liquid hazardous waste prohibited	RCRA hazardous waste; placement	40 CFR 264.18(c)
Historic project-owned or controlled by Federal agency	Action to preserve historic properties; planning of action to minimize harm to National Historic Landmarks	Property included in or eligible for the National Register of Historic Places	National Historic Preservation Act, Section 106 (16 USC 470 <u>et seq.</u>); 36 CFR 800
Critical habitat upon which endangered species or threatened species depends	Action to conserve endangered species or threatened species, including consultation with the Department of Interior	Determination of presence of endangered or threatened species	Endangered Species Act of 1973 (16 USC 1531 <u>et seq.</u>); 50 CFR 200, 50 CFR 402; Fish and Wildlife Coordination Act (16 USC 661 <u>et seq.</u>); 33 CFR 320-330; TN Rare Plant Protection and Conservation Act of 1985 (TCA § 11-26-201); TN Non-Game and Endangered and Threatened Wildlife Species Act of 1974 (TCA § 51-901).
Wetlands(b)	Action to prohibit discharge of dredged or fill material into wetlands without permit	Wetlands as defined in U.S. Army Corps of Engineers regulations	Clean Water Act section 404; 40 CFR 230, 33 CFR 320-330; Executive Order 11990, "Protection of Wetlands."
	Action to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands to the extent possible	Action involving construction of facilities or management of property in wetlands, as defined by 40 CFR 6, Appendix A, section 4 (j)	40 CFR 6, Appendix A
Wilderness area	Area must be administered in such manner as will leave it unimpaired as wilderness and to preserve its wilderness	Federally-owned area designated as wilderness area	Wilderness Act (16 USC 1131 <u>et seq.</u>); 50 CFR 35.1 <u>et seq.</u> ; TN Natural Areas Protection Act of 1971 (TCA § 11-1701).

TABLE 7-6 (Continued)

Location	Requirement	Prerequisite for Applicability	Citation
Wildlife refuge	Only actions allowed under the provisions of 16 USC Section 668 dd(c) may be undertaken in areas that are part of the National Wildlife Refuge System	Area designated as part of National Wildlife Refuge System	16 USC 668dd <u>et seq.</u> ; 50 CFR 27.94
Area affecting stream or river	Action to protect fish or wildlife; prohibits diversion, channeling, or other activity that modifies a stream or river that affects fish or wildlife	Presence of fish and wildlife resources	Fish and Wildlife Coordination Act (16 USC 661 <u>et seq.</u>); 40 CFR 6.302

(a) Source: Adapted from U.S. EPA (1988).

(b) 40 CFR Part 6 Subpart A sets forth EPA policy for carrying out the provisions of Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands). Executive orders are binding on the level (e.g., Federal, State) of government for which they are issued.

are identified covering a particular situation or if potential ARARs are determined not to be protective, other criteria, advisories, guidance, or proposed standards may be used; and the reasons for their use will be documented.

7.3 PRELIMINARY IDENTIFICATION OF OBJECTIVES FOR SITE CLOSURE AND CORRECTIVE ACTION

This section identifies site closure and corrective action objectives for WAG 6. The objectives apply to both hazardous chemical and radioactive constituents. The objectives are based on EPA closure performance standards and on a preliminary comparison of levels of contaminants detected at WAG 6 with levels established in various standards (see Section 7.2).

The objectives identified in this report are both general and preliminary. A final statement of site objectives will follow completion of the site-specific human health assessment.

This section has two parts. Background information regarding RCRA closure performance standards and RCRA corrective action program objectives are described in Section 7.3.1. Section 7.3.2 presents a statement of preliminary site closure and corrective action objectives for WAG 6.

7.3.1 Background

7.3.1.1 RCRA Closure Performance Standard. As specified in 40 CFR 265.11 and Tennessee Rule 1200-1-11-.05(7)(b), the technical objectives for final closure of SWSA 6 are to:

- o Control, minimize, or eliminate, to the extent necessary to protect human health and the environment, post-closure escape of:
 - 1) hazardous substances;
 - 2) leachate and contaminated runoff; and
 - 3) hazardous waste decomposition products to the ground, surface water, groundwater, or the atmosphere.

- o Minimize the need for further maintenance.

A site closure alternative is selected based on knowledge of the types of wastes and waste forms disposed at the site, an understanding of the site physical characteristics (particularly hydrogeology), and the effectiveness of the technologies proposed. For WAG 6, the site closure alternative must be consistent with the alternative selected for corrective action.

7.3.1.2 RCRA Corrective Action Program Objectives. The Hazardous and Solid Waste Amendments (HSWA) to RCRA, passed by Congress on November 8, 1984, require any facility seeking a RCRA permit to conduct a corrective action program for releases of hazardous wastes or constituents from SWMUs. Specifically, RCRA Section 3004(u) requires a corrective action program for releases of hazardous materials from any SWMU, regardless of the time at which the waste was placed in the unit; and RCRA Section 3004(v) requires a corrective action program beyond the facility property boundary, where it is necessary to protect human health and the environment.

The WAG 6 corrective measures program consists of three steps: 1) the RFI, 2) the CMS, and 3) Corrective Measures Implementation. The WAG 6 RFI Report, to be issued in the fall of 1990, will include a description of the nature and extent of contamination, a baseline human health assessment, and development and initial screening of corrective action alternatives.

The initial step in the development of corrective measure alternatives is the establishment of corrective action objectives. According to draft regulations proposed by the EPA in September, 1988, corrective actions should:

- o Attain media cleanup standards (discussed below).

- o Control the sources of releases so as to reduce or eliminate further releases of hazardous wastes that may pose a threat to human health and the environment (corresponds to closure performance standard).

The media cleanup standards referenced above would be set as follows:

- o For known or suspected carcinogens, cleanup standards would be established at concentration levels which represent an excess upper bound lifetime cancer risk to an individual of 1×10^{-4} to 1×10^{-7} .
- o For systemic toxicants, cleanup standards would represent concentration levels to which the population could be exposed on a daily basis without appreciable risk of deleterious effect during a lifetime.
- o For groundwater and surface water that is a current or potential source of drinking water, cleanup standards would need to consider Maximum Contaminant Levels promulgated under the Safe Drinking Water Act.

Media cleanup standards based on specific exposure scenarios will be presented in the WAG 6 RFI report. In this Site Characterization Summary Report, preliminary media cleanup standards are identified based on the environmental criteria listed in Section 7.2.

7.3.2 Preliminary Site Closure and Corrective Action Objectives for WAG 6

Based on the regulatory requirements described in the preceding section and on a preliminary comparison of contaminant concentrations detected at WAG 6 with environmental criteria (Section 5.0), site closure and corrective action objectives are identified as follows:

1. Implement site closure to control, to the extent necessary to protect human health and the environment, post-closure escape of:
 - a) hazardous and/or radioactive materials;
 - b) leachate and contaminated runoff; and
 - c) hazardous waste decomposition products to the soil, surface water, groundwater, or atmosphere.

2. Implement closure technologies that will minimize the need for site maintenance required to achieve Objective 1.
3. Implement corrective action to control, to the extent necessary to protect human health and the environment, past releases of contaminants to groundwater and surface water. (Past releases from waste areas are identified in Section 5.0.)

It is of fundamental importance to recognize that the details of the site-specific exposure scenarios developed in the human health assessment will dictate what remediation should be performed and when it should be performed. For example, if the range of exposure scenarios requires protection of an off-site receptor from the groundwater pathway immediately following closure, then groundwater plume extraction and treatment may be required. However, if the range of exposure scenarios does not involve an off-site receptor exposed to groundwater until 30 years hence, then source control technologies and natural processes (e.g., volatilization, chemical decomposition by microbes, dilution) alone may be sufficient to lower concentrations to those protective of human health.

8.0 PRELIMINARY IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section identifies and screens technologies applicable to RCRA closure and corrective action at WAG 6. The identified technologies are based on the preliminary site objectives developed in Section 7.0. Site objectives will be revised upon completion of the baseline risk assessment during Phase II of the RFI. The RFI Report will include final identification and screening of technologies, and assembly and initial screening of remedial alternatives.

This section consists of three parts. Section 8.1 provides an overview of EPA's recommended process for developing and evaluating alternatives. Section 8.2 identifies general response actions applicable to the preliminary site objectives, and identifies technologies that fall within each general response action. Section 8.3 describes each technology and includes a brief assessment of the applicability of the technology to WAG 6.

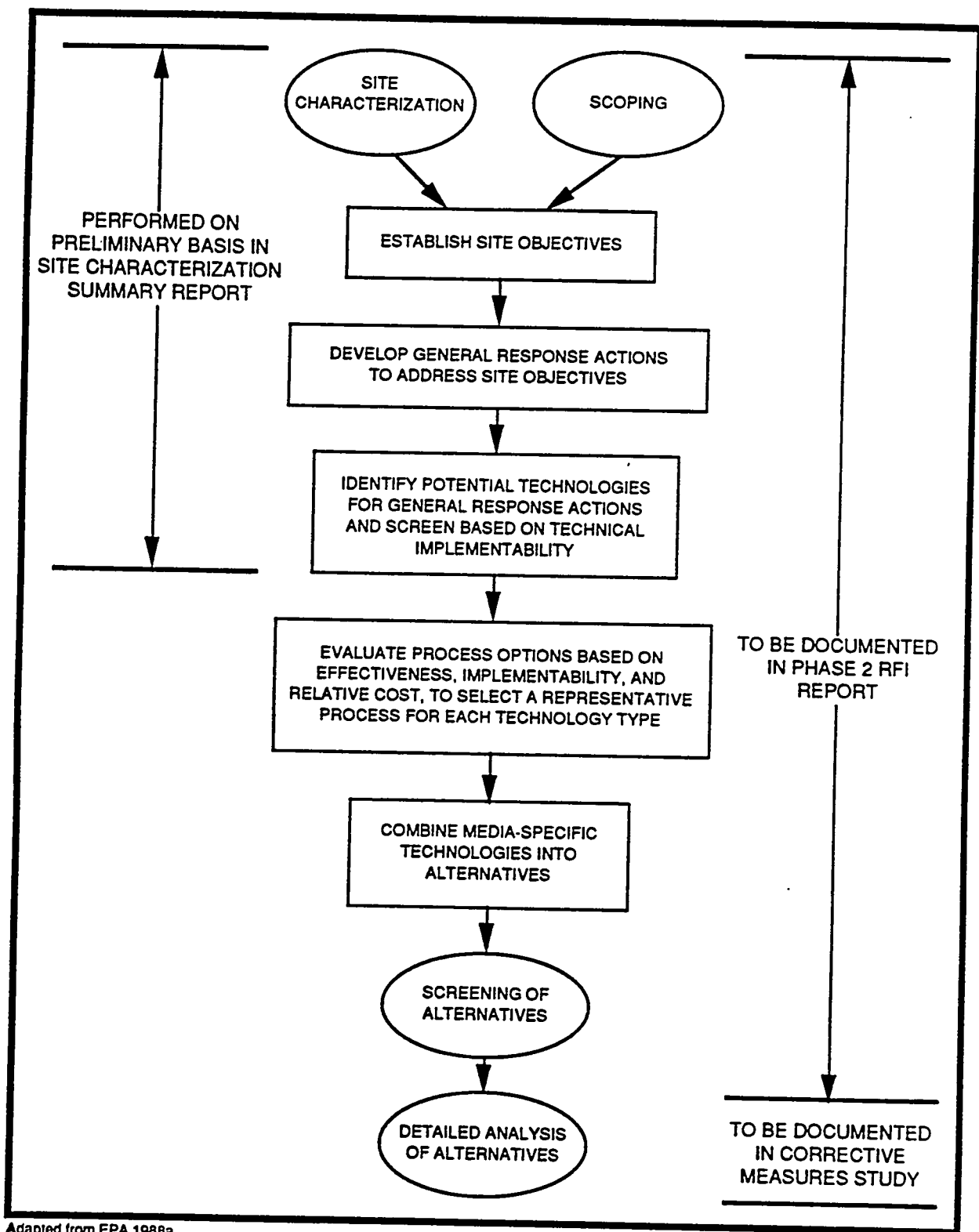
8.1 ALTERNATIVES DEVELOPMENT AND EVALUATION PROCESS

This section provides a brief overview of the EPA Superfund process that will be employed to develop and evaluate alternatives for RCRA closure and corrective action for WAG 6. The Superfund (CERCLA) process is described in detail in Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (U.S. EPA, 1988f), and is substantially identical to that described for RCRA corrective action programs in RCRA Corrective Action Plan (U.S. EPA, 1988g). The CERCLA process was adopted because it specifies in the greatest detail the steps that should be followed, and because ORNL desires to be in general compliance with both RCRA and CERCLA guidance.

Figure 8-1 illustrates the alternatives development process, which consists of the following general steps:

- o Develop site closure and corrective action objectives based on: chemical- and radionuclide-specific standards (when available); site-specific, risk-related factors; and other criteria as appropriate (e.g., RCRA closure performance standards).
- o Develop a list of general types of actions appropriate for each medium of interest (e.g., containment, treatment, removal) that may be taken singly or in combination to satisfy the objectives defined in the previous step. These general types or classes of actions are generally referred to as general response actions in EPA guidance.
- o Identify and screen technology groups for each general response action. For example, the general response action of containment can be further defined to include the capping and vertical barrier technology groups. Screening should eliminate those groups that are not technically feasible at the site.
- o Identify and evaluate technology process options for each technology group to select a representative process for each group under consideration. Although specific process options are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology group. For example, a soil bentonite slurry wall may be selected as representative of vertical barriers and would be used for technical and cost comparisons.
- o Assemble the selected representative technologies into site closure and corrective action alternatives representing a range of treatment and containment combinations, as appropriate.
- o Screen the assembled alternatives against the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives will be evaluated in less detail than subsequent evaluations.

The preceding six steps will be documented in the WAG 6 Phase II RFI Report. The final step, involving a detailed analysis of each alternative, will be performed during the Corrective



Adapted from EPA 1988a

FIGURE 8-1
ALTERNATIVES DEVELOPMENT AND ANALYSIS

Measures Study. During detailed analysis, each alternative is evaluated against the nine specific evaluation criteria listed below:

- o Overall protection of human health and the environment
- o Compliance with ARARs
- o Long-term effectiveness and permanence
- o Reduction of toxicity, mobility, or volume
- o Short-term effectiveness
- o Implementability
- o Cost
- o State acceptance
- o Community acceptance

The above criteria are described in EPA (1988a). The initial two criteria are considered as threshold criteria, in that all alternatives must satisfy these before further consideration. The next five criteria are considered the primary criteria on which the analysis is based. The final two criteria, state and community acceptance, are addressed during the final decision-making process after completion of the CMS.

8.2 IDENTIFICATION OF GENERAL RESPONSE ACTIONS

Preliminary WAG 6 closure and corrective action objectives are described in Section 7.0. This section identifies general response actions which, singly or in combination, may be applicable to achieving these objectives.

8.2.1 Listing of General Response Actions

General response actions are defined as those broad classes of actions that may satisfy the objectives defined for WAG 6. Table 8-1 provides a list and description of general response actions and typical technologies associated with each action.

TABLE 8-1

GENERAL RESPONSE ACTIONS, TYPICAL ASSOCIATED REMEDIAL TECHNOLOGIES, AND EVALUATION

General Response Action	Description	Typical Technologies	Applicability of General Response Action to Potential Pathways	
No action	No remedial action taken at site.	Some monitoring and analyses may be performed.	National Contingency Plan requires consideration of no action as an alternative. Would not address potential pathways, although existing access restrictions would continue to control on-site contact.	
Relocation	Moving residents or others on or near contaminated area to another area permanently or temporarily.	Relocate residents or on-site or off-site workers temporarily or permanently.	<u>Not applicable.</u> No residents on ORR near WAG 6. Nearest residents are on south side of Clinch River. The only workers on or near the site are ORNL radiation workers.	
Access and use restrictions	Permanent prevention of entry into contaminated area of site. Control of land use.	Site security, fencing, deed use restrictions, warning signs.	Could control on-site exposure and reduce potential for off-site exposure. Site security fence and some signs are in place. Additional short-term or long-term access restriction would likely be part of most remedial actions.	
Containment	In-place actions taken to prevent migration of contaminants.	Capping; groundwater containment barriers; soil stabilization; enhanced vegetation.	If applied to source, could be used to control all pathways. If applied to transport media, could be used to mitigate past releases (except air).	
Pumping	Transfer of accumulated subsurface or surface contaminated water, usually to treatment and disposal.	Groundwater pumping; leachate collection; liquid removal from surface impoundments.	Applicable to trench leachate removal prior to in situ treatment or waste removal. Applicable to removal of contaminated groundwater and bulk liquids (e.g., from buried drums).	
Removal	Excavation and transport of primarily nonaqueous contaminated material from area of concern to treatment or disposal area.	Excavation and transfer of tanks; drums; soils; sediments; wastes; contaminated structures.	If applied to source, could be used to control all pathways. If applied to transport media, will control corresponding pathway. Must be used with treatment or disposal response actions to be effective.	
Treatment	Application of technology to change the physical or chemical characteristics of the contaminated material. Applied to material that has been removed.	Incineration; solidification; land treatment; biological, chemical and physical treatment.	Applied to removed source material, could be used to control all pathways. Applied to removed transport media, could control air, surface water, groundwater, and sediment pathways.	

TABLE 8-1 (continued)

General Response Action	Description	Typical Technologies	Applicability of General Response Action to Potential Pathways
In situ treatment	Application of technologies in situ to change the in place physical or chemical characteristics of contaminated material.	In situ vitrification, densification, flushing, bioremediation.	Applied to source, could be used to control all pathways. Applied to transport media, could be used to control corresponding pathways.
Storage	Temporary stockpiling of removed material in a storage area or facility prior to treatment or disposal.	Temporary storage structures.	May be useful as a means to implement removal actions, but by definition would not be considered a final action for pathways.
Disposal	Final placement of removed contaminated material or treatment residue in a permanent storage facility.	Landfills; repositories.	With source removal, could be used to control all pathways. With removal of contaminated transport media, could be used to control corresponding pathway (except air).
Alternative water supply	Provision of uncontaminated water to individuals or communities through use of a substitute source of water or point of use treatment.	Cisterns; aboveground tanks; deeper or upgradient wells; municipal water system; relocation of intake structure; individual treatment devices.	Not applicable. No residents on ORR near WAG 6. Nearest residents are south of Clinch River.
Floodwater control	Actions taken to control movement of floodwater entering or leaving the site.	Levees, dikes.	Not applicable. Waste disposal areas would not be subjected to flooding during 100-year event.
Monitoring	Short and/or long term monitoring is implemented to assess site conditions and contamination levels.	Sediment, soil, surface water, and groundwater sampling and analysis.	RCRA will likely require post-closure monitoring to assess performance of closure and corrective action implementation.

The table also includes a general statement regarding the applicability of the general response action to the potential exposure pathways identified in Section 7.0.

8.2.2 Application of Response Actions to Potential Exposure Pathways

The response actions outlined in Table 8-1 must be applied to the potential exposure pathways that have been identified for WAG 6. The response actions can either be capable of providing control over all or some of the potential pathways. Partially effective response actions can be combined to form complementary sets of response actions that provide control over all pathways.

In general terms, potential human exposure may be avoided by prevention of contaminant release, transport, and/or contact. Thus, application of the response actions may be considered at three different points in each potential exposure pathway: 1) at the point where the contaminant could be released from the source, 2) in the transport medium, and 3) at the point where the contact with the released contaminant could be prevented.

In Figure 8-2, response actions are applied to each potential migration pathway. The application of the response actions is based on the evaluation of the response actions made in Table 8-1. As noted in Table 8-1, some response actions must be used with others to form a complete action; several of the response actions are shown combined in Figure 8-2, such as removal and treatment, removal and disposal, and surface water diversion and collection and treatment.

8.3 IDENTIFICATION OF TECHNOLOGIES

Multiple remedial technologies exist for each general response action. Figure 8-3 identifies and provides brief descriptions of remedial technologies for the general response actions identified in Figure 8-2. Technologies listed range from those that are

PATHWAY-SOIL			
SWMUs		CONTAMINATED SOIL GENERATED BY: <ul style="list-style-type: none"> • SURFACE SPILLS FROM ONGOING OPERATIONS <div style="border: 1px solid black; padding: 2px; display: inline-block;">REDUCE, ELIMINATE, OR MODIFY OPERATIONS</div> • CONTACT WITH CONTAMINATED SURFACE WATER <div style="border: 1px solid black; padding: 2px; display: inline-block;">IN-PLACE CONTAINMENT (E.G., CAP)</div> • DEPOSITION OF AIR-SUSPENDED PARTICLES <div style="border: 1px solid black; padding: 2px; display: inline-block;">SEE GENERAL RESPONSE ACTIONS IDENTIFIED FOR AIR PATHWAY</div> 	CONTAMINANT AVAILABILITY: <ul style="list-style-type: none"> • SOIL <div style="border: 1px solid black; padding: 2px; display: inline-block;">CONTAINMENT (E.G., CAP)</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">REMOVAL OF CONTAMINATED SOIL</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">REMOVAL OF CONTAMINATED SOIL</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">IN SITU TREATMENT</div>
PATHWAY-AIR			
SWMUs		AIRBORNE CONTAMINANTS GENERATED BY: <ul style="list-style-type: none"> • WIND EROSION • VOLATILIZATION <div style="border: 1px solid black; padding: 2px; display: inline-block;">CONTAINMENT (E.G. CAPPING) OF CONTAMINATED SOILS</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">REMOVAL OF CONTAMINATED SOILS</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">DISPOSAL</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">REMOVAL OF CONTAMINATED SOILS</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">TREATMENT</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">IN SITU TREATMENT OF CONTAMINATED SOILS</div> • ONSITE ACTIVITY: <div style="border: 1px solid black; padding: 2px; display: inline-block;">REDUCE / ELIMINATE / MODIFY ACTIVITY</div> 	CONTAMINANT TRANSPORT: <ul style="list-style-type: none"> • AIR <div style="border: 1px solid black; padding: 2px; display: inline-block;">NO FEASIBLE TECHNIQUES FOR REMOVING CONTAMINANTS FROM AIRBORNE AT WAG</div>
PATHWAY-GROUNDWATER			
SWMUs		CONTAMINATED GROUNDWATER GENERATED BY: <ul style="list-style-type: none"> • CONTACT WITH WASTE • CONTACT WITH CONTAMINATED SOIL <div style="border: 1px solid black; padding: 2px; display: inline-block;">IN-PLACE CONTAINMENT (E.G., CAP) OF WASTE / CONTAMINATED SOIL</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">REMOVAL OF WASTE / CONTAMINATED SOIL</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">DISPOSAL</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">REMOVAL OF WASTE / CONTAMINATED SOIL</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">TREATMENT</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">IN SITU TREATMENT OF WASTE/SOIL</div> 	CONTAMINANT TRANSPORT: <ul style="list-style-type: none"> • GROUNDWATER FLOW <div style="border: 1px solid black; padding: 2px; display: inline-block;">CONTAINMENT OF GROUNDWATER FLOW</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">VERTICAL BARRIERS</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">PUMPING OF CONTAMINANTS</div>
PATHWAY-SURFACE WATER			
SWMUs		CONTAMINATED SURFACE WATER GENERATED BY: <ul style="list-style-type: none"> • CONTACT WITH CONTAMINATED SOIL <div style="border: 1px solid black; padding: 2px; display: inline-block;">IN-PLACE CONTAINMENT (E.G., CAP) OF CONTAMINATED SOIL</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">REMOVAL OF CONTAMINATED SOIL</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">DISPOSAL</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">REMOVAL OF CONTAMINATED SOIL</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">TREATMENT</div> • DISCHARGE OF CONTAMINATED GROUNDWATER TO SURFACE WATER <div style="border: 1px solid black; padding: 2px; display: inline-block;">SEE GENERAL RESPONSE ACTIONS IDENTIFIED FOR GROUNDWATER PATHWAY</div> 	CONTAMINANT TRANSPORT: <ul style="list-style-type: none"> • SURFACE WATER FLOW <div style="border: 1px solid black; padding: 2px; display: inline-block;">REMOVAL (E.G. DIVERSION)</div>

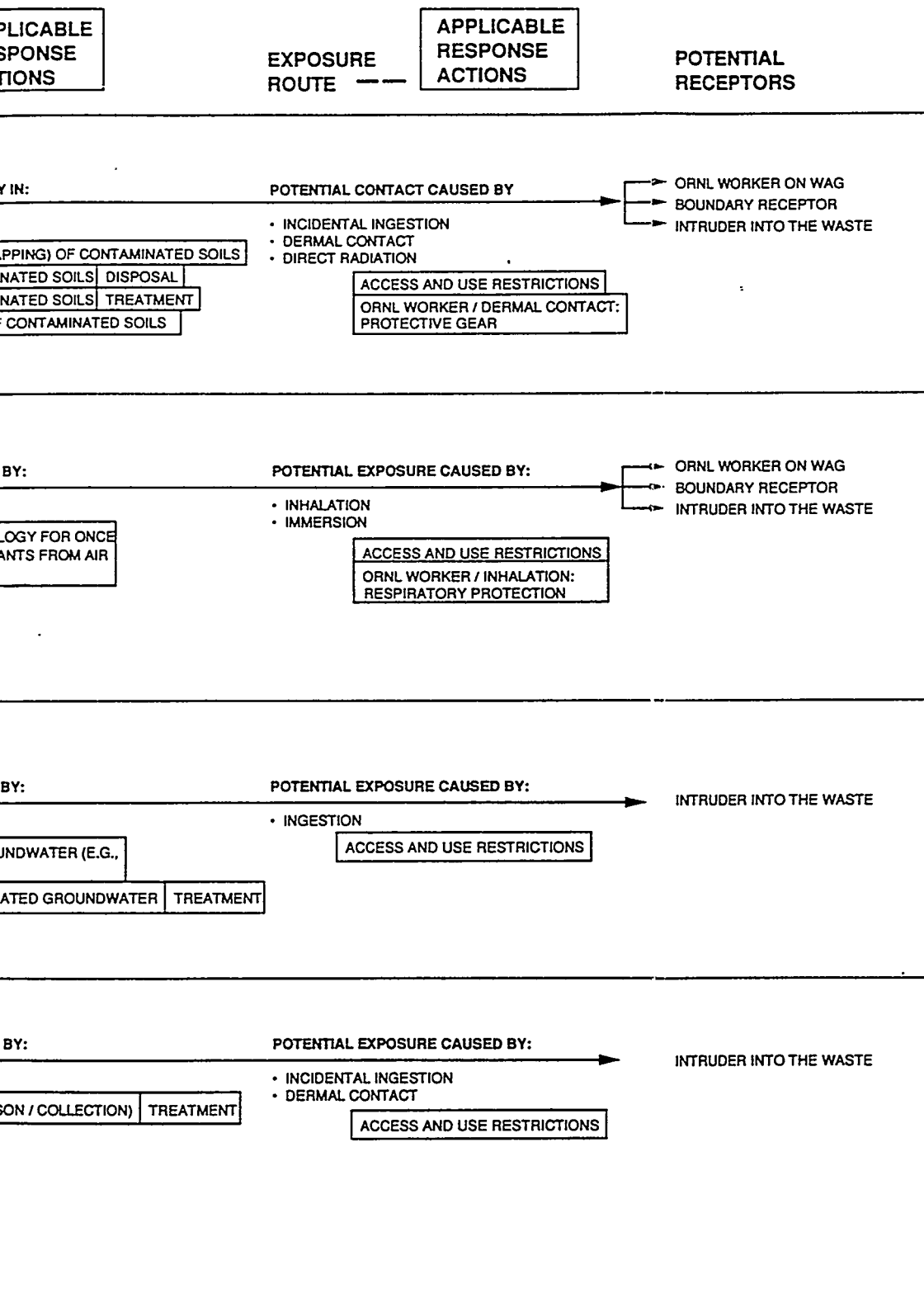


FIGURE 8-2
POTENTIAL REMEDIAL
ACTIONS BY PATHWAY

SOURCE	RELEASE MECHANISM — —	APPLICABLE RESPONSE ACTIONS	TRANSPORT MEDIUM — —
PATHWAY—SEDIMENTS			
SWMUs	<p>CONTAMINATED SEDIMENTS GENERATED BY:</p> <ul style="list-style-type: none"> • PRECIPITATION -CAUSED EROSION OF CONTAMINATED SURFACE SOILS • FLOODING-CAUSED EROSION OF CONTAMINATED SURFACE SOILS <p>IN-PLACE CONTAINMENT (E.G. CAP) OF CONTAMINATED SOILS</p> <p>REMOVAL OF CONTAMINATED SOILS DISPOSAL</p> <p>REMOVAL OF CONTAMINATED SOILS TREATMENT</p> <p>IN SITU TREATMENT OF CONTAMINATED SOILS</p> <ul style="list-style-type: none"> • CONTACT WITH CONTAMINATED SURFACE WATER <p>SEE GENERAL RESPONSE ACTIONS IDENTIFIED FOR SURFACE WATER PATHWAY</p> <ul style="list-style-type: none"> • EROSION OF CONTAMINATED SOILS EXPOSED BY ON-SITE OPERATIONS <p>TEMPORARY CONTAINMENT OF ERODED SOIL</p> <p>SURFACE WATER CONTROLS</p> <p>REDUCE, ELIMINATE, OR MODIFY ACTIVITY</p>	<p>CONTAMINANT TRA</p> <ul style="list-style-type: none"> • SEDIMENT TRANS <p>IN-PLACE CO</p> <p>REMOVAL OF</p> <p>REMOVAL OF</p> <p>IN SITU TREA</p>	
PATHWAY—BIOTA FOOD CHAIN			
SWMUs	<p>CONTAMINANTS IN FOOD CHAIN GENERATED BY:</p> <ul style="list-style-type: none"> • TERRESTRIAL BIOTA UPTAKE/EXPOSURE FROM CONTAMINATED SOIL, SEDIMENTS, SURFACE WATER • AQUATIC BIOTA UPTAKE / EXPOSURE FROM CONTAMINATED SURFACE WATER AND SEDIMENTS <p>SEE GENERAL RESPONSE ACTIONS IDENTIFIED FOR SOIL, SURFACE WATER, AND SEDIMENT PATHWAYS</p>	<p>CONTAMINANT AVA</p> <ul style="list-style-type: none"> • MOVEMENT THRO <p>ANIMAL BARRI</p> <p>NO FEASIBLE T</p> <p>REMOVAL OF C</p> <p>OTHER THAN F</p>	

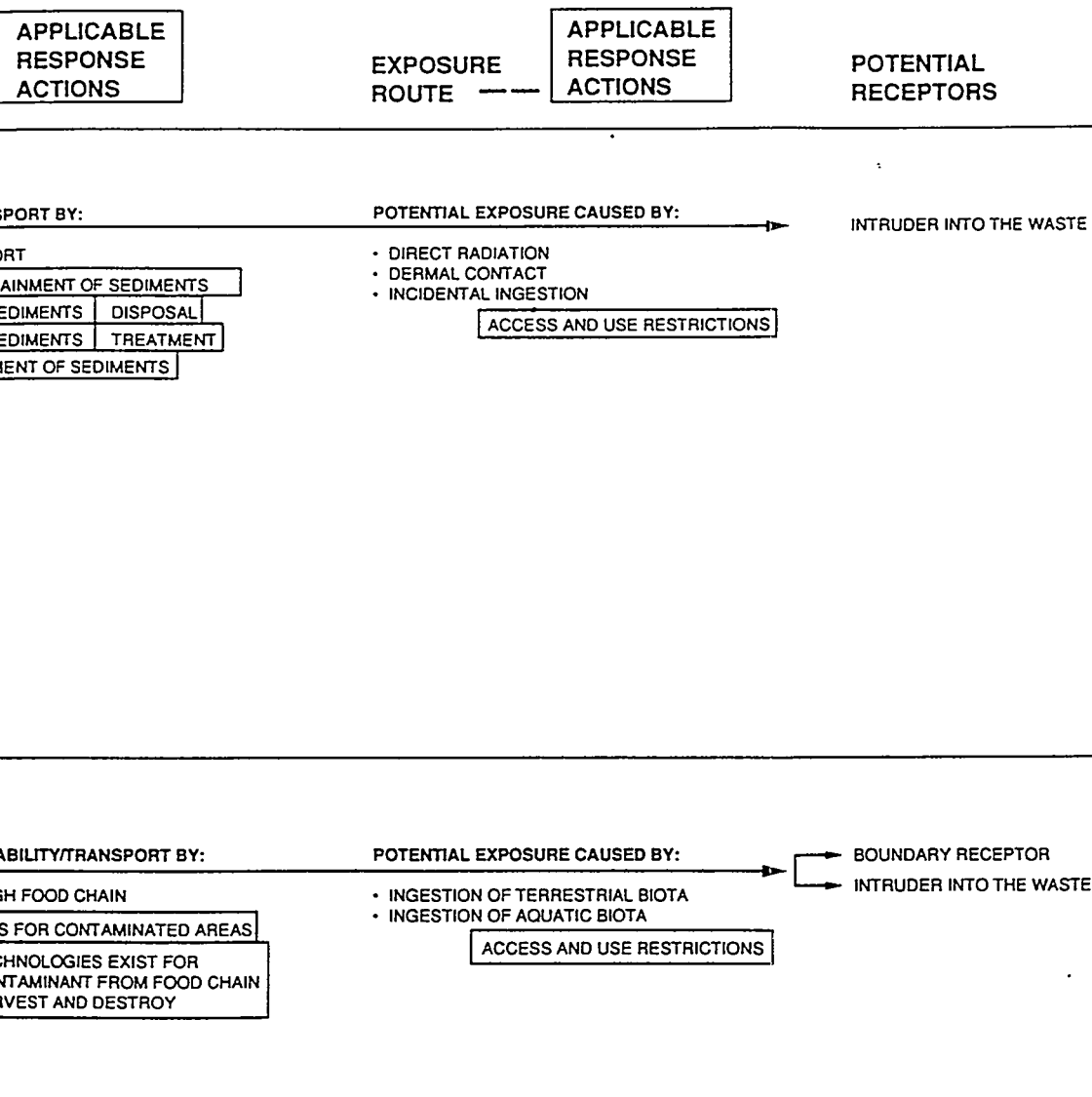


FIGURE 8-2 (CONTINUED)
POTENTIAL REMEDIAL
ACTIONS BY PATHWAY

GENERAL RESPONSE ACTION

REMEDIAL TECHNOLOGY

DESCRIPTION

NO ACTION

NONE

NO ACTION

ACCESS AND USE RESTRICTIONS

ACCESS AND USE RESTRICTIONS

EXAMPLES
FENCES TO

CONTAINMENT

CAPPING

IMPERMEABLE
ELIMINATE

VERTICAL BARRIERS

WALLS THAT
AREAS, OR

IN-SITU BARRIERS

LOW-PERMEABLE

SURFACE CONTROLS

SURFACE
IMPLEMENTED

SEDIMENT CONTROL BARRIERS

A PHYSICAL
BY SEDIMENT

DUST AND VAPOR SUPPRESSION

TARPS, SOIL

PUMPING AND REMOVAL

BULK LIQUID PUMPING

BULK LIQUID
MOST COMMON

GROUNDWATER PUMPING

GROUNDWATER
DISPOSED.

LANDFILL GAS COLLECTION

GASES EMITTED

DRUM & DEBRIS REMOVAL

DRUMS AND
EQUIPMENT

EXCAVATION

CONTAMINATED

DECONTAMINATION

CONTAMINATED
CONTAMINATED

TION

REMEDIAL RESPONSES INITIATED AT SITE ARE ABANDONED; NO MONITORING.

INCLUDE LEGAL RESTRICTIONS ON DEEDS TO REGULATE LAND USE; PERMITS TO REGULATE GROUNDWATER USE; REGULATE SITE ACCESS; SIGNS TO WARN POTENTIAL INTRUDERS.

COVER MATERIALS ARE PLACED OVER WASTE DISPOSAL AREAS AND CONTAMINATED SOILS TO REDUCE OR INFILTRATION, PREVENT EROSION, AND TO PROVIDE INTRUSION BARRIER.

ARE LESS PERMEABLE THAN THE IN SITU SOIL ARE PLACED UPGRADIENT OR DOWNGRADIENT OF WASTE DISPOSAL MAY BE USED TO ENCIRCLE WASTE DISPOSAL AREAS.

ABILITY MATERIAL IS PLACED INTO VOID SPACES TO REDUCE THE PERMEABILITY OF THE IN SITU WASTE OR SOIL.

LING, GRADING, SOIL STABILIZATION, REVEGETATION, AND SURFACE WATER DIVERSION/COLLECTION ARE TO REDUCE SITE RUNON/RUNOFF, SURFACE WATER INFILTRATION AND EROSION, AND TO STABILIZE SURFACE SOILS.

BARRIER, FILTER SCREEN, OR CAP IS CONSTRUCTED TO MINIMIZE THE SPREAD OF CONTAMINANTS MIGRATION.

COVERS, SPRAYS, ETC. ARE APPLIED TO SUPPRESS DUST AND NON-POINT-SOURCE VAPOR.

IN OPEN PITS, OPEN PONDS, TANKS, DRUMS, ETC., ARE REMOVED BY A VARIETY OF METHODS, ONLY BY PUMPING.

R AND LEACHATE ARE COLLECTED IN WELLS OR TRENCH DRAINS AND PUMPED SO THEY CAN BE TREATED AND

ATING FROM WASTE DISPOSAL AREAS ARE INTERCEPTED BY A PASSIVE OR ACTIVE (PUMPED) SYSTEM.

OR DEBRIS ARE REMOVED BY VARIOUS MECHANICAL MEANS, E.G., CRANES AND OTHER STANDARD CONSTRUCTION

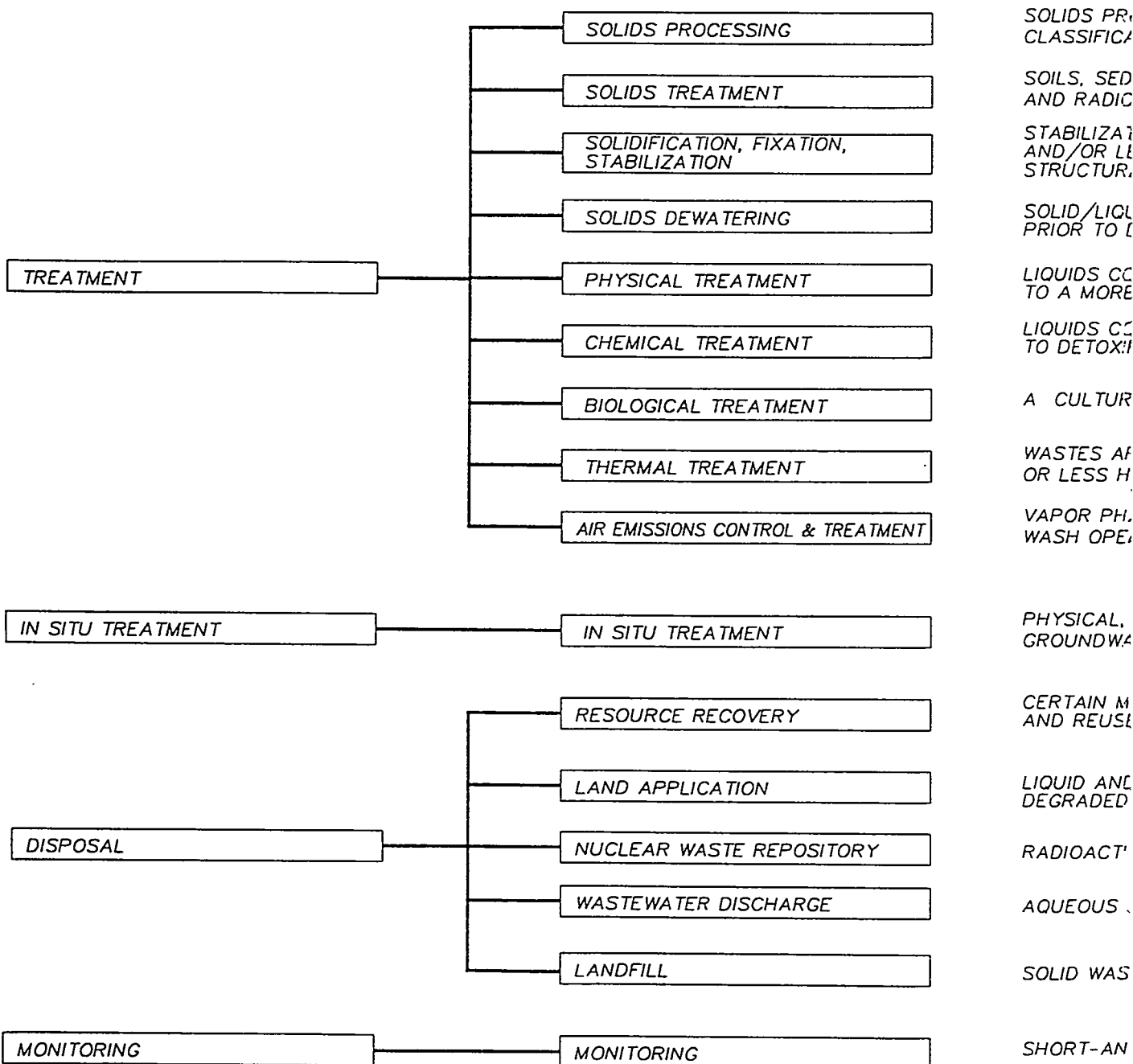
ED SOIL, SEDIMENT, SLUDGES AND OTHER SOLIDS ARE REMOVED WITH STANDARD CONSTRUCTION EQUIPMENT.

ED BUILDINGS, BUILDING MATERIALS OR OTHER STRUCTURES ARE WASHED WITH A SUBSTANCE THAT REMOVES ITS UPON RINSING. OFTEN DECONTAMINATION IS DONE WITH A PRESSURIZED STREAM.

GENERAL RESPONSE ACTION

REMEDIAL TECHNOLOGY

DESCRIPTION



TION

CESSING PREPARES SOLID WASTES FOR FURTHER TREATMENT OR DISPOSAL BY SIZE REDUCTION OR
ON OR MATERIAL SEPARATION.

ENTS, AND OTHER SOLIDS ARE PHYSICALLY OR CHEMICALLY TREATED TO REMOVE THE HAZARDOUS
CTIVE CONSTITUENTS OR CONVERT THE CONSTITUENTS TO NONHAZARDOUS SUBSTANCES.

N AND FIXATION PROCESSES MAINTAIN HAZARDOUS AND RADIOACTIVE CONSTITUENTS IN THEIR LEAST TOXIC
ST MOBILE FORM. SOLIDIFICATION PRODUCES A MONOLITHIC BLOCK OF TREATED WASTE WITH HIGH
INTEGRITY.

D SEPARATION RECOVERS SOLIDS AND LIQUIDS, OR REMOVES EXCESS LIQUID FROM SEDIMENTS AND SLUDGES
POSAL.

MAINTAINING HAZARDOUS CHEMICALS OR RADIOACTIVE CONSTITUENTS ARE TREATED TO CONVERT THE CONSTITUENTS
EASILY HANDLED FORM THROUGH EQUALIZATION, CONCENTRATION, AND/OR PHASE CHANGE.

MAINTAINING HAZARDOUS CHEMICALS OR RADIOACTIVE CONSTITUENTS ARE ALTERED BY CHEMICAL REACTIONS
HAZARDOUS CHEMICALS OR TO CONVERT THE CHEMICALS OR RADIONUCLIDES TO A MORE EASILY TREATED FORM.

OF MICROORGANISMS METABOLIZES BIODEGRADABLE ORGANIC MATERIALS.

EXPOSED TO HIGH TEMPERATURES TO TRANSFORM THE HAZARDOUS COMPOUNDS INTO INNOCUOUS
RMFUL SUBSTANCES. THERMAL TREATMENT WILL NOT DECREASE RADIOACTIVITY.

THE IMPURITIES ARE REMOVED FROM LANDFILL GASES THROUGH PROCESSES RANGING FROM ONCE-THROUGH
TIONS TO MULTIPLE-STEP RECYCLE SYSTEMS.

CHEMICAL, AND BIOLOGICAL PROCESSES ARE EMPLOYED TO TREAT CONTAMINATED SOIL, SOLID WASTES OR
ER IN PLACE.

ERALS, METALLIC PRODUCTS AND RADIOISOTOPES CAN BE RECLAIMED FROM HAZARDOUS/RADIOACTIVE WASTES

SOLID WASTES THAT ARE PRIMARILY ORGANIC ARE INCORPORATED INTO THE UPPER SOIL HORIZON SO THEY CAN BE
TRANSFORMED, OR IMMOBILIZED.

WASTES ARE DISPOSED OF IN A LICENSED LOW LEVEL OR HIGH LEVEL RADIOACTIVE WASTE REPOSITORY.

REAMS ARE DISCHARGED TO A TREATMENT PLANT, SURFACE WATER, OR SHALLOW OR DEEP WELLS.

S ARE PERMANENTLY DISPOSED OF IN A LANDFILL. LANDFILLS CANNOT ACCEPT LIQUID WASTES.

FOR LONG-TERM MONITORING IS IMPLEMENTED TO ASSESS SITE CONDITIONS AND CONTAMINATION LEVELS.

commonplace (e.g., capping) to those that are experimental (e.g., in situ vitrification). The technologies identified in Figure 8-3 are described in greater detail and are subjected to preliminary screening in Section 8.4.

8.4 PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES

The following paragraphs provide added definition of the remedial technologies identified in Section 8.3, and include a preliminary site-specific screening for applicability to WAG 6. The results of the screening are summarized in Table 8-2.

8.4.1 Access and Use Restrictions

Restrictions on the use of the site may be either physical or regulatory. Security fences can be installed around a site and adjacent areas to control access. To regulate future use of the site, legal restrictions may be put on deeds for property. Deed restrictions can prevent disturbance of surface controls and sediment control barriers as well as future well construction. Residential, commercial, and, in some cases, recreational (hunting and fishing) uses and activities may need to be controlled.

WAG 6 is currently under the control of ORNL and will likely remain so for at least the next 30 years. The existing access and use restrictions (e.g., security fence) will likely be upgraded and remain in effect as part of any alternative for site closure and corrective action.

8.4.2 Containment Technologies

8.4.2.1 Capping. Capping is employed to cover buried wastes to prevent their exposure at the ground surface and to reduce infiltration of surface water into the waste. The design of caps

TABLE 8-2
SCREENING OF TECHNOLOGIES

General Response Actions	Technology	Screening Comments		Retained for Further Analysis
		Site-Specific Considerations	Waste Specific Considerations	
NO ACTION	None	The National Contingency Plan requires that no action be carried through to detailed analysis of alternatives.	The National Contingency Plan requires that no action be carried through to detailed analysis of alternatives.	Yes
ACCESS AND USE RESTRICTIONS	Signs, fences, site security, deed restrictions.	Existing signs and fences are effective; upgrading fences may be necessary to control deer. Security patrol not a substitute for fence because topography restricts view of perimeter. Deed restrictions appropriate if property transferred.	If wastes are closed in place, access and use restrictions will reduce potential from exposure to waste and contaminated media on site.	Yes
CONTAINMENT	Capping	Wastes generally disposed on topographic highs; allows effective control of infiltration. Some steep topography locally. Trench wastes may settle.	Wastes disposed in trenches and auger holes; contaminant transport caused by surface water and groundwater flow into/through wastes.	Yes
	Vertical Barriers	In some areas there is groundwater flow from upgradient in to waste areas. Some steep slopes locally.	Contaminant transport caused in part by flow of uncontaminated groundwater through wastes.	Yes
	In-Situ Barriers	Infiltration/flow of water through void spaces generate leachate. Collapse of waste into void spaces causes surface depressions.	Wastes are in trenches and auger holes. Waste in trenches exhibits void space of about 25%.	Yes
	Surface Controls	Steep topography and clayey soils result in considerable high velocity runoff. Soil cover over trenches susceptible to erosion.	Surface water infiltration into wastes and erosion of soil cover reduced by surface controls.	Yes
	Sediment Control Barriers	Surface water runoff erodes surface soil into drainages and sediments downstream toward WOC/WOL.	Sediments are contaminated with radionuclides (primarily Sr-90).	Yes

TABLE 8-2 (continued)

General Response Actions	Technology	Screening Comments			Retained for Further Analysis
		Site-Specific Considerations	Waste Specific Considerations	Technology Considerations	
CONTAMINMENT (cont'd)	Dust and vapor suppression	Existing grass cover reduces dust generation from surface soils. Minimal dust generated from creek beds because of vegetation and moisture.	Surface soils appear to be uncontaminated except for occasional local "hot spots." Sediments are contaminated in some areas. Vapor emissions not detected over trench areas. (Dust and vapors likely during excavation and/or removal.)	Techniques common in site remediation industry.	Yes
	PUMPING AND Bulk liquid pumping REMOVAL		EWB is the only impoundment at WAG 6. Few if any drums are likely to be recovered intact from trenches.	Common practice.	No
	Groundwater/leachate removal	Clayey overburden is of relatively low permeability, however 49-Trench and drain demonstrated effectiveness of groundwater removal.	Many trench wastes are submerged periodically and some continuously. Leachate removal is required prior to in situ treatment.	Common practice. Performance often difficult to assess.	Yes
	Landfill gas collection	Wastes disposed in individual shallow trenches and auger holes. Wastes were not landfilled in large volumes at great depths.	Except for biological trench areas, wastes contain relatively low levels of organic materials. Methane in breathing air over biological trench areas not at hazardous levels.	Common construction. Cap would be designed to vent methane, but collection system not required.	No
	Drum and Debris removal	Minor amounts of debris are located in several areas. Removal of debris, pipe, etc. incidental to closure and corrective action.	Debris is not expected to be contaminated.	Common practice.	Yes
	Excavation	Site conditions (waste content, form, geometry) make waste excavation infeasible except for perhaps small volumes.	Trench and auger hole wastes of highly variable contaminant content and waste form. Worker exposure potential would be high.	Excavation very difficult. Trench waste form varies from trash in plastic sacks to metal desks to concrete casks. Due to geometry and close spacing of auger holes, specialized equipment would be required to remove auger hole wastes. Contamination control difficult.	Yes (small volumes only)

TABLE 8-2 (continued)

General Response Actions	Technology	Screening Comments			Retained for Further Analysis
		Site-Specific Considerations	Waste Specific Considerations	Technology Considerations	
REMOVAL	Decontamination	Building 7842 and some equipment are used for ongoing LLW disposal operations at WAG 6.	If excavated, trench-disposed wastes include casks and containers that could be surface-decontaminated prior to redisposal. Ongoing waste management operations may result in some surface contamination of structures or equipment.	Common practice for structures and equipment.	Yes
TREATMENT	Solids processing	For wastes (if excavated), some processing would be required prior to subsequent treatment or disposal. If sediments excavated, processing unlikely.	Highly variable waste form. Sediments (contaminated at low levels) are relatively homogeneous.	Common practice. Contamination control and worker exposure potential concerns at WAG 6.	Yes
	Solids treatment	Would be unnecessary for redisposal of removed wastes using greater confinement disposal (GCD) techniques.	Highly variable waste content and form. Treatment difficult. Sediments contaminated with low levels of radionuclides--treatment unnecessary.	Require waste homogenization; would be difficult for trench and auger hole wastes.	Yes
	Solidification, fixation, stabilization	Removed wastes, soils, and sediments may be wet, making handling and contamination control difficult.	Highly variable waste form. Processing to remove excess water from excavated wastes difficult. Sediments and soils relatively homogeneous.	Wide variety of techniques. Most applicable to homogeneous waste form.	Yes (wet soils and sediments)
	Solids dewatering	Removed wastes, soils, and sediments may be wet, making handling and contamination control difficult.	Highly variable waste form. Sediments relatively homogeneous, but volumes would be small; solidification agents technically more appropriate.	Requires homogeneous feed. Technically inappropriate for small scale work with variable feed.	No
	Physical treatment	Trench leachate would need to be removed and treated prior to trench stabilization. Groundwater collection may be required of dynamic compaction employed to stabilize trenches.	Trench leachate composition highly variable. Groundwater contaminant composition variable.	Potentially applicable for trench leachate and groundwater treatment. Bench-scale studies required.	Yes (water treatment)
	Chemical treatment	Trench leachate would need to be removed and treated prior to trench stabilization. Groundwater collection may be required of dynamic compaction employed to stabilize trenches.	Trench leachate composition highly variable. Groundwater contaminant composition variable.	Potentially applicable for trench leachate and groundwater treatment. Bench-scale studies required.	Yes (water treatment)

TABLE 8-2 (continued)

General Response Actions	Technology	Screening Comments		Retained for Further Analysis
		Site-Specific Considerations	Waste Specific Considerations	Technology Considerations
TREATMENT (cont'd)	Biological treatment	Trench leachate would need to be removed and treated prior to trench stabilization. Groundwater collection may be required of dynamic compaction employed to stabilize trenches.	Trench leachate composition highly variable. Groundwater contaminant composition variable.	Potentially applicable for trench leachate and groundwater treatment. Bench scale studies required.
	Thermal Treatment		For solid wastes, highly variable waste form (e.g. contaminated laboratory equipment/furniture) precludes incineration without extensive solids processing. Sediments contaminated with radionuclides. Soils contaminated with generally very low levels of chemicals.	Will not destroy radioactivity. Cs-137 will volatilize. No
IN SITU TREATMENT	Air emission control and treatment	Most likely application would be as part of thermal treatment process.	Air emissions from in place wastes are not considered a hazard to human health.	Common practice in industrial application. No
	Physical, chemical, biological or thermal in situ treatment	Approximately 500 trenches and 500 auger holes; treatments would likely have to be applied to trenches individually.	Mixed waste content and highly variable; not conducive to effective use of chemical, biological, or thermal treatment. Physical treatment in form of dynamic compaction and void space grouting are being field demonstrated.	Would not reduce radioactivity. Most in situ technologies undemonstrated on large scale. Wastes generally must be well characterized and homogeneous. Yes (Physical Methods)
DISPOSAL	Resource Recovery	Wastes located in approximately 500 trenches and 500 auger holes.	Wastes poorly characterized and highly variable. Contaminants are largely not sufficiently valuable to recover.	Must have well-characterized, relatively homogeneous waste material. No
	Land Application	Site has considerable topography. Almost all level areas have been used for waste disposal.	Trench and auger hole mixed wastes highly variable content and form. Not appropriate for land application. Sediments are contaminated with radionuclides; not appropriate for land application.	Not applicable to radioactive materials or solid wastes. No

TABLE 8-2 (continued)

General Response Actions	Technology	Screening Comments		Retained for Further Analysis
		Site-Specific Considerations	Waste Specific Considerations	
DISPOSAL (cont'd)	Nuclear repository		Most site wastes may be categorized as mixed hazardous and low level radioactive solid wastes. Wastes known to contain LLW only are disposed by GCD techniques. There is a reportedly a TRU cask stored in WAG 6.	Commercial LLW disposal sites operated by the states and compacts exempted from receiving federal waste from nuclear weapons production research. High-level waste repositories will likely not be operating when WAG 6 closed. Interim storage required.
	Wastewater discharge	Trench leachate removal likely and groundwater removal possible during trench waste stabilization.	Trench leachates are contaminated at varying levels and will likely require treatment prior to discharge. Groundwater removal and treatment may be required during trench stabilization operations.	Common practice for treated wastewaters and waters posing no health or environmental risks.
MONITORING	Landfill	Site exhibits considerable topography. Sufficient level ground to construct a facility for small volumes of waste only (relative to total volume disposed at site).	Most site waste may be categorized as mixed hazardous and low-level radioactive solid waste. Wastes known to contain LLW only are disposed by GCD techniques.	Landfill would have to comply with NRC-EPA joint guidance for disposal of mixed hazardous and radioactive wastes. No commercial facilities available to receive such wastes from ORNL.
	Monitoring	Site is large, exhibits considerable topography, and less complex hydrogeology.	Wastes disposed in unlined trenches and auger holes on five different local topographic highs.	Common practice. Performance of any closure and corrective action would be difficult to assess without monitoring.

usually conforms to the performance requirements in 40 CFR 264.310, which address RCRA landfill closure and post-closure. These requirements include minimum liquid migration through the wastes, low cover maintenance requirements, efficient site drainage, high resistance to damage by settling or subsidence, and a permeability lower than or equal to the underlying liner system or natural soils. Most cap designs are multilayered to conform with the above-mentioned design standards.

In general, capping is performed when extensive subsurface contamination at a site precludes excavation and removal of wastes because of potential hazards and/or unrealistic costs, as may be the case at WAG 6. Installed as part of a RCRA interim corrective measure, temporary synthetic caps are currently in place over the RCRA-regulated units within WAG 6. Because of the hazards associated with waste removal and the difficulty in locating an acceptable alternate permanent disposal location, capping will likely be considered for final closure and corrective action at WAG 6.

The main disadvantages of capping are the need for long-term maintenance and uncertain design life. Caps must be periodically inspected for settlement, erosion, and invasion by animals and deep-rooted vegetation. Trenches in WAG 6 may be expected to subside significantly if not stabilized before capping. Such subsidence would result from the degradation of trench wastes. Dynamic compaction and trench grouting appear to be the most promising techniques for stabilizing trenches prior to capping. The presence of relatively high groundwater levels in the lower areas of the site may limit a cap's ability to significantly decrease groundwater contamination in these areas. In such cases, other technologies may need to be implemented to lower the groundwater level to below the trench bottoms (e.g., trench drains).

8.4.2.2 Vertical Barriers. Vertical barriers generally consist of subsurface walls that are of lower permeability than the in situ soil. Vertical barrier technologies include soil-bentonite slurry walls, cement-bentonite slurry walls, grout curtains, sheet pile walls, and ground freezing. Barriers may be located upgradient, downgradient, or may be used to encircle wastes that are buried below the groundwater table. An upgradient barrier may be used to reduce the amount of uncontaminated groundwater flowing into a contaminated area, while a downgradient barrier may be used to restrict the migration of contaminated groundwater away from a contaminated area.

An alternate type of vertical barrier is a trench drain from which groundwater is removed (either by gravity flow or pumping) for treatment and/or disposal, as necessary. A trench drain could be used to intercept and divert the flow of uncontaminated groundwater away from wastes, to collect groundwater already contaminated (thus acting as a barrier to further migration), and to lower the groundwater levels in specific areas. This latter approach has already been used at WAG 6 (49-trench area drain).

Vertical groundwater barriers of one type or another are likely candidates for inclusion in alternatives for closure and corrective action for WAG 6. However, because of the placement of wastes along topographic highs and the steep slopes around the perimeter of many waste disposal areas, it is likely that they will only be feasible in selected areas. For example, vertical barriers may be appropriate at the northern perimeter of the central and west disposal areas to prevent the flow of uncontaminated upgradient groundwater into downgradient trench areas.

Installation of vertical barriers at WAG 6 should be straight forward, although some sloughing of trench walls during construction is likely to occur based on past experience. Installation on moderate to steep slopes will likely be

infeasible, however, construction on shallow slopes should be possible, provided a "bench" is graded into the slopes for equipment. One potential difficulty may be keying the wall into rock, however, specialized equipment is available for this. Alternatively, it may not be necessary to key vertical barriers into rock if the purpose is to divert near-surface flow. Low permeability slurry walls are not effective for controlling tritium-contaminated groundwater.

8.4.2.3 In Situ and Subsurface Horizontal Barriers. The construction of horizontal barriers generally consists of placing a low permeability material in an existing void space, injecting a low permeability material into a void space created by high-pressure pumping, or freezing of the water in the voids. The integrity of barriers created by these methods are relatively difficult to evaluate during construction. Such barriers are frequently used in conjunction with a vertical barrier to divert water movement away from buried wastes. The horizontal barriers constructed using in situ techniques are experimental and are used primarily in soils. These barriers should not be depended on to provide either a continuous barrier or a barrier having a consistent thickness.

Because waste disposal areas at WAG 6 are generally located above the water table, the major focus of subsurface remediation will likely be reducing surface water infiltration and intercepting subsurface flow that might come in contact with wastes. It is unlikely that subsurface horizontal barriers will be useful in achieving these ends. In those areas where wastes are below the groundwater table (e.g., in the biological trench area at the south end of the site), construction of subsurface horizontal barriers would be infeasible due to subsurface variability, difficulty of verification, and necessity of drilling within the waste disposal areas (which would result in significant risks of worker exposure).

In situ grouting of trench wastes has been proposed and field-demonstrated by ORNL as a technology for both stabilizing trench wastes to minimize long-term subsidence and to substantially increase the hydraulic isolation of the wastes to minimize leaching. Such grouting, while not creating a horizontal barrier, is similar in concept and also increases hydraulic isolation of wastes. There is a significant chance that grouting of trench voids will be considered for alternatives for final closure and corrective action of WAG 6.

8.4.2.4 Surface Controls. Surface controls are often performed in conjunction with management of migration or site closure. Surface controls are generally well-established, inexpensive techniques and are almost always employed with other technologies (e.g., pumping and treatment, or excavation and removal). Surface control technologies include surface seals, grading, soil stabilization, revegetation, and diversion and collection systems. Selection of specific surface controls must take into account topography, soil type, drainage area, etc. Contaminated runoff, if it occurs, normally requires treatment prior to discharge.

Surface water control technologies are designed to prevent site runoff/runoff to reduce surface water infiltration, to reduce erosion, and to stabilize the surface soils. These controls minimize leachate generation and reduce off-site migration. The topography of WAG 6 makes the use of surface water controls such as diversion and collection systems important for erosion control, and it is likely that such measures will be included in site closure alternatives.

8.4.2.5 Sediment Control Barriers. When removing contaminated stream sediments, it may be necessary to control sediments to minimize migration of contaminants. This may be accomplished by installing silt fences or constructing a cap over the contaminated sediments.

Control of sediment in the runoff from excavations can be done with the many types of sediment control techniques commonly used in construction. These include hay bales, plastic fabric filter cloth, detention ponds, gravel surfacing, and vegetation.

Because closure and corrective action for WAG 6 will almost certainly involve site grading (and thus exposure of soils to erosion), sediment control techniques will likely be employed.

8.4.2.6 Dust and Vapor Suppression. Temporary methods for non-point sources of dust and vapor include membranes and tarps, mulches and soil covers, water, organic polymers, and foam sprays. Permanent or semipermanent dust suppression methods also include such standard civil engineering techniques as application of asphalt pavement, asphalt emulsions, or oiling of roads. Most dust control methods are well developed. There have been recent improvements in some of the organic polymer formulations that allow them to work for longer periods and control organic vapors.

The two application areas for dust and vapor suppression in waste cleanup are temporary stabilization/control during remediation activities and permanent or semipermanent control for long-term containment. Dust suppression will probably be required during construction of remedial measures at WAG 6, particularly if significant earthwork is involved.

8.4.3 Removal Technologies

8.4.3.1 Bulk Liquid Pumping. Based on currently available data, removal of bulk liquids is not expected to comprise a large part of the remediation process for WAG 6. However, bulk liquids could be encountered in buried drums in some trenches. Bulk liquid could also collect in pits during waste excavation.

Bulk liquids can be removed by a variety of methods including dredging, bailing, pumping, vacuuming, draining, fixation and excavation, or pouring. The method used is dependent on the amount of material, its chemical and physical characteristics (e.g., chemical and radiological constituents, volatility, flammability, reactivity, tendency to polymerize in air, percent solids), and the type of container in which it is found. Prior to removal or disposal of bulk liquids, appropriate sampling and analysis should be conducted.

8.4.3.2 Groundwater/Leachate Removal. A trench drain has already been utilized for a portion of WAG 6. Since groundwater contamination exists in WAG 6, it is likely that a groundwater collection system may be considered for part of final closure and corrective action for WAG 6. Groundwater and leachate could be collected in wells or trench drains and removed so they can be treated or disposed.

Groundwater collection is used to limit the lateral or vertical migration of contaminants while gradually removing them from the groundwater system. Collection systems can be designed for nearly any aquifer system where the hydrogeologic setting is characterized and understood. However, the considerable topographic relief at WAG 6 will complicate design of such a system. Conventional systems work best when the hydraulic conductivity of the formation is greater than 1×10^{-4} cm/sec.

8.4.3.3 Landfill Gas Collection. Gas production is a natural process that occurs through the bacterial decomposition of organic matter in a burial ground. Gas movement into areas surrounding waste burial areas occurs by both convection and diffusion. The extent and rate of gas movement varies with the type of cover material, surrounding soil characteristics, and climatic conditions. The lateral movement of methane in a burial ground can be intercepted by either permeable or impermeable barriers.

The generation of large volumes of methane after closure from wastes buried at WAG 6 is not expected; and consequently, it is unlikely that site closure will include gas collection. However, despite the fact that large volumes are not expected, any caps constructed over waste disposal areas would be designed to allow venting to the atmosphere.

8.4.3.4 Drum and Debris Removal. Drums and debris are usually removed as part of an emergency response or an operable unit designed for source control. The removal of drums and other containers tends to lessen the risk of contaminant release, and when combined with debris removal, portions of a waste site are more accessible for other phases of investigation or remedial activities.

Closure of WAG 6 will involve removal of a variety of stockpiled materials located at the site (e.g., lumber and pipe). If waste excavation is performed at WAG 6, separation of drums, debris, and soil after removal from trenches may depend upon requirements imposed by the operator of the destination disposal area.

8.4.3.5 Excavation. Excavation to remove contaminated material involves either the use of standard construction equipment or special equipment adapted to minimize disturbance of the deposit. Equipment sizes vary depending upon the volume of material to be removed and site characteristics. The selection of specific equipment is usually based on contractor preference; however, the designer may specify certain equipment for special circumstances. The type of equipment depends largely upon the water table location and the water content, consistency, and strength of the deposits to be excavated.

Closure and corrective action for WAG 6 will likely involve grading and earthwork, however it is uncertain at this time if

actual excavation of contaminated materials for treatment and/or disposal will be technically feasible. Source removal will help control all potential exposure pathways identified in Section 7.0. However, the potential exposures to workers during construction may outweigh this benefit. Another concern is the availability of a mixed waste disposal facility licensed to accept these wastes. Feasibility of excavation of contaminated materials can only be determined during the detailed evaluation of alternatives and thus should not be eliminated from consideration.

8.4.3.6 Decontamination. Several buildings are located at WAG 6. If they are found to be contaminated, decontamination may be a viable alternative to disposal. The nature of the structure and its contamination will be factors in determining if decontamination is appropriate. Decontamination may be performed using a variety of washing techniques and more aggressive techniques such as sand blasting. Disposal of used decontamination media may be an important consideration.

8.4.4 Treatment Technologies

8.4.4.1 Solids Processing. Solids processing of hazardous and radioactive waste is a generic grouping of physical pretreatment processes. These physical processes are used alone or in combination to prepare the waste for "final" destructive thermal or chemical treatment or disposal. The usual objectives of solids processing are to achieve a uniform and appropriately sized composite or to minimize, by physical means, the volumes of waste. Appropriately sized particles may be those that can "liberate" the waste for treatment or those fine enough to enhance any subsequent treatment step. These processes may include removal of tramp iron and steel, crushing and grinding, and sizing by screens or classifiers.

At WAG 6, solids processing may be applicable for sediments, soils, or buried wastes removed for treatment and/or disposal.

8.4.4.2 Solids Treatment. Solids treatment involves exposing the solid in question to materials that will remove the hazardous constituents or will convert the hazardous constituents to nonhazardous substances. Solids treatment technologies include neutralization, oxidation, and chemical reduction of sludges; other chemical modifications of solids; water and solvent leaching; and solvent evaporation. Radioactive wastes will not become less radioactive as a result of solids treatment unless the radionuclides are actually removed from the waste. However, the chemical fraction of mixed waste may be treated, leaving the radioactive portion for disposal.

At WAG 6, solids treatment will likely not constitute a significant part of site closure and remedial action. Levels of contamination in soils will probably not warrant removal, and sediments (if removed) would probably be disposed of on-site without solids treatment. If wastes are excavated, solids treatment may be appropriate, but potential worker exposures may preclude excavation.

In summary, solids treatment cannot be eliminated from further consideration, although there is not a high likelihood that it will be used.

8.4.4.3 Solidification, Fixation, and Stabilization Applications. Solidification eliminates free liquids, usually by physical absorption. Stabilization or fixation chemically alters waste contaminants to reduce mobility or leaching. These processes also solidify wastes and improve physical properties. Monolithic blocks can be produced, but more commonly, the treated material has a granular soil texture and can be transported using earth moving equipment.

Solidification and stabilization processes increase waste-bearing strength to support capping materials, eliminate free liquids, and reduce the solubility, mobility, and leachability of contaminants. Improving physical characteristics also improves waste handling and reduces the surface area available for leaching and chemical reactions. These processes are usually used prior to land disposal. However, they can be applied after waste excavation with mechanical mixing equipment or with earth moving equipment. They can also be applied in situ with special injection equipment as during trench grouting field demonstrations at WAG 6.

At WAG 6, alternatives for site closure and corrective action will likely use some technology for trench stabilization prior to capping. Dynamic compaction and in situ grouting of the wastes are currently being investigated by ORNL. Otherwise, stabilization/solidification is likely to be used for handling contaminated soils and sediments that are very wet and for dealing with liquid spills. Stabilization/solidification generally result in increased volumes of material requiring disposition.

8.4.4.4 Solids Dewatering. Solid/liquid separation processes produce two output streams. One stream is water or relatively solids-free liquid that may or may not require further treatment. The second stream is a concentrated volume of solids that must be placed in a landfill, undergo additional treatment, or be reused or recovered. Solid/liquid separations include the following categories: gravity sedimentation, filtration, centrifugation, and evaporation. Technologies include sedimentation; gravity thickening; screens hydraulic classifiers and scalpers; centrifuges; belt filter presses; filter presses; vacuum filtration; dewatering and drying beds; and sludge dryers.

Solids dewatering will probably not be a significant technology included in alternatives for WAG 6 closure. If sediment removal

is included, wet sediments would most likely be solidified using a solidification agent due to the relatively small volumes involved. Wet soils/sludges that might be excavated as part of waste removal would probably also be solidified due to variability of waste form. Solids dewatering associated with treatment of trench leachate and groundwater is considered incidental to treatment.

8.4.4.5 Physical Treatment. Physical treatment processes change the hazardous constituents to a more easily handled form through equalization, concentration, and/or phase change. Physical treatment often separates the waste into two streams, one dilute and the other a concentrated volume of material that must be placed in a landfill or undergo additional treatment. Many physical processes are used in combination with other treatment processes.

Physical treatment technologies include flow and strength equalization, coagulation and flocculation, oil-water separation, flotation, media filtration, adsorption, membrane processes, freeze crystallization, air (or gas) stripping, steam stripping, evaporation, distillation, liquid-liquid extraction, and critical-fluid extraction.

Physical treatment processes are most likely to be used at WAG 6 as part of the treatment system for trench leachates and groundwater. It is unlikely that physical treatment will be appropriate for other media.

8.4.4.6 Chemical Treatment. In chemical treatment, hazardous constituents are altered by chemical reactions. In the process, hazardous compounds may be either destroyed or the resultant products may still be hazardous but in a form more convenient for further processing. Chemical treatment technologies include neutralization of liquids, precipitation, ion exchange, oxidation, reduction, organic chemical dechlorination,

photolysis, irradiation, other chemical treatments, and greensand.

At WAG 6, chemical treatment is most likely to be used as part of the treatment process for trench leachates and groundwater.

8.4.4.7 Biological Treatment. Biological treatment involves contacting a wastewater with a culture of microorganisms, either suspended in the wastewater or attached to a solid medium. The organic compounds in the wastewater are metabolized by the organisms as a food and energy source. The result is the removal of organics from solution and the production of biomass and metabolic waste gases such as carbon dioxide and methane.

Biological treatment may be considered for the treatment process for trench leachates and groundwaters removed at WAG 6.

8.4.4.8 Thermal Treatment. Thermal treatment exposes waste material to a high temperature for a specific period of time. When heated in the presence of sufficient oxygen for combustion (incineration), the waste is chemically transformed into innocuous substances such as carbon dioxide and water, while also producing ash and a certain amount of oxides and acid gases, depending on the composition of the waste and the process conditions under which it is oxidized. When heated in the absence of oxygen (pyrolysis), the waste decomposes, producing a residue and a variety of vapor-phase compounds that can then be incinerated.

Thermal treatment is an appropriate method for the destruction or treatment of combustible organic liquids, gases, or solids. Wastes containing large fractions of noncombustible solids have been treated thermally, most notably electrical capacitors and soils contaminated with PCBs and other organics. At WAG 6, chemical contaminant levels in soils and sediments do not appear to warrant thermal treatment. If some wastes are excavated,

thermal treatment might be applicable following solids processing. With some exceptions (e.g., cesium becomes volatile at greater than 500°C), radiologic contaminants would remain and be concentrated, but chemical and biological contaminants would be reduced. However, due to the highly variable waste forms in SWSA 6, it is improbable that thermal treatment would be feasible.

8.4.4.9 Air Emissions Control and Treatment. Gas treatment processes vary from simple once-through wash operations to complex multiple-step recycle systems. The more complicated systems are usually associated with product recovery systems. Gas treatment technologies include condensation, particulate removal, adsorption, absorption, catalytic conversion, and thermal destruction.

Reduction of pollutants from discharge of an incinerator is the most likely application of air emissions control and treatment to WAG 6. However, as previously stated, it is unlikely that thermal treatment would be appropriate for soils and sediments, and unlikely that it would be technically feasible for trench wastes.

8.4.5 In Situ Treatment

In situ treatment technologies are used for treating contaminated soils or wastes until an acceptable level of treatment is achieved, and for protecting groundwater and surface water resources without physically isolating the contaminated wastes or removing them. Treatments include processes for degradation, immobilization, and detoxification of specific target waste constituents in the soil system.

Immobilization techniques are designed to capture chemical species within the contaminated soil mass. Three major classes of immobilization techniques are adsorption, ion exchange, and

precipitation. Degradation techniques may refer to biological, chemical, and photochemical reactions. Biological degradation refers to the use of soil microorganisms, primarily bacteria, actinomycetes, and fungi (for the metabolism of organic compounds), and some inorganic compounds, leading to the decomposition, detoxification, and mineralization of the parent compound(s). Chemical degradation techniques convert contaminant species through the processes of oxidation, reduction, precipitation, and polymerization. Photochemical degradation (photolysis) utilizes the action of ultraviolet radiation for the breakdown of many organic compounds.

In situ treatment technology includes neutralization, oxidation, reduction, precipitation, bioreclamation, in situ radio frequency heating, steam stripping, permeable treatment beds, vitrification, soil vapor extraction, soil flushing, and other in situ treatment.

In situ treatment is attractive for WAG 6 because the hazards of excavation and transporting wastes are reduced; however, the low permeability of the soil and variable nature of the waste tends to limit usefulness of many in situ techniques. In situ grouting and dynamic compaction of wastes to reduce void space and reduce waste surface area accessible for leaching have already been demonstrated at WAG 6. In situ thermal treatment of trench-disposed wastes may be considered for WAG 6. It may be accomplished by injecting high temperature gas into the waste or by using an array of electrodes as used for in situ vitrification. In situ thermal treatment for such wastes is undemonstrated, however, and presents significant potential for contaminated emission to escape and the potential for explosions.

8.4.6 Disposal Technologies

8.4.6.1 Resource Recovery. The two basic types of resource recovery are the recovery of a raw material or product, or the recovery of the fuel value in a waste. In WAG 6, the most likely candidates for resource recovery are radionuclides. However, because the disposal methods employed in the past would make recovery expensive, it is unlikely that any of the radionuclides disposed in WAG 6 will be sufficiently valuable in the near future to justify recovery.

8.4.6.2 Land Application. Land application involves the incorporation of liquid and solid wastes into the upper soil horizon. Chemical constituents of the waste are degraded, transformed, or immobilized through chemical, physical, and biological actions in the soil.

Land application of contaminated soils, sediments, and other materials is highly unlikely due to the presence of radionuclides. On-site land application is infeasible due to the potential for exposing wastes during tilling operations.

8.4.6.3 Nuclear Waste Repositories. The federal government is performing a site investigation at Yucca Mountain in an effort to establish a deep geological high-level waste repository. This repository will be primarily for commercial high-level nuclear wastes, but some defense wastes may also be disposed of there. However, this repository will not be open until after WAG 6 closure is scheduled to be completed. Thus, it is not considered feasible for disposal. The Waste Isolation Pilot Project in New Mexico will possibly start receiving transuranic wastes within the next several years. Strict limits will be imposed, but this repository may be considered for WAG 6 wastes that meet requirements.

Other federal sites might also be considered for disposal of WAG 6 low level wastes. The commercial LLW disposal sites operated by the state governments and compacts are exempted from requirement to receive federal waste derived from nuclear weapons production or research.

8.4.6.4 Wastewater Discharge. The term "wastewater discharge" generally includes the disposal of groundwater or surface water that contains concentrations of contaminants as well as treated wastewaters. The parameters that influence the choice of wastewater disposal method include: the characteristics and concentration of contaminants in the wastewater; the quantity of wastewater; the characteristics of the candidate receiving stream, treatment works, aquifer, or impoundment; the duration of the discharge; and the economics of the situation. Wastewater discharge of some type will most likely be involved with WAG 6 remediation, since final closure and corrective action may yield trench leachate and groundwater. ORNL is currently conducting a bench scale treatment study for WAG 6 trench leachates.

8.4.6.5 Landfilling. As noted in the discussion of removal technologies, it is uncertain if trench and auger hole waste removal will be considered feasible at WAG 6 due to concerns for worker exposures. Alternatives developed that include removal must address disposal technologies. If the waste excavated is radioactive but is not classified as hazardous by EPA, then it could be redispersed in SWSA 6 or in some other federal LLW disposal site using techniques that provide greater confinement. If the waste is classified as radioactive and hazardous (i.e., mixed waste) then the waste can only be disposed of in a facility meeting the standards established both by the NRC for low-level radioactive wastes and by EPA for hazardous wastes. Finally, if the waste is classified as hazardous, but not radioactive, then it can be disposed of in a hazardous waste landfill.

The greatest proportion of wastes that might be excavated at WAG 6 fall into the first two categories.

8.4.7 Monitoring

Sampling of soil, sediment, groundwater, surface water, and air, and analysis for chemicals and radionuclides will likely be conducted to some extent to assess the performance of site closure and corrective action at WAG 6. Such monitoring is common practice for waste remediation and is generally conducted in accordance with regulatory guidance.

9.0 CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the conclusions of the initial activities of the WAG 6 Phase 1, Activity 1 site characterization investigation, and gives recommendations for additional data needs required to complete the Phase 1 investigation.

The WAG 6 fate and transport analysis and the baseline human health evaluation are being developed, and some additional data needs may be identified as a result of these analyses. Data acquisition will be integrated into the second round of sampling activities.

9.1 CONCLUSION

The health-based criteria have not yet been developed for a number of contaminants detected at WAG 6. Results from radiological, chemical, and biological sampling and analyses are discussed in the subsections below.

9.1.1 Radiological Results

Radionuclides detected at WAG 6 include tritium, cobalt-60, strontium-90, cesium-137, plutonium-238, plutonium 239/240, americium-241, and curium-244. Health-based criteria for drinking water were available only for tritium and strontium-90. The concentrations of both radionuclides exceed the criteria for surface water and groundwater.

Naturally occurring radionuclides were also detected at WAG 6; however, background data for naturally occurring radionuclides are not available yet. Thus, it is unknown if the detected levels of these nuclides are elevated with respect to background. Site-specific background samples for soils have been recently collected and surface water and groundwater will be collected in

early spring, 1990. Data from these efforts will be presented in the final RFI report.

9.1.2 Chemical Results

Levels of inorganic compounds detected in soils were within ranges of typical background values for the U.S. The environmental criteria (which were developed in Section 7.0) for drinking water were exceeded at 12 groundwater and 3 surface water sampling locations. However, these concentrations have not yet been evaluated with reference to the background concentrations.

Fourteen VOCs and one SVOC were detected in surface water and groundwater samples at levels exceeding environmental criteria. They were primarily identified in surface water and groundwater.

9.1.3 Biological Results

A limited microbiological hazard investigation was performed at WAG 6 to identify potential health and safety concerns. Results of this investigation identified no definitively pathogenic organisms. The most significant finding was the discovery of a previously unidentified pasteurella-like bacteria in groundwater samples. In laboratory tests, the bacteria did not appear to be highly virulent; however, live bacteria were recovered from the tissue of the infected mice.

9.1.4 Summary of Conclusions

Contaminants are not uniformly distributed on WAG 6. Based on inventory records approximately 90% of the radioactive and organic solvent wastes were disposed of in a small, localized area. Based on data collected during the Phase 1, Activity 1 soil contamination identified in WAG 6 was confined to the

immediate area around the disposal trenches and auger holes. Based on both historical data and RFI Phase 1, Activity 1 results, radionuclide concentrations were observed to be the lowest in leachate, intermediate in groundwater and highest in surface waters. Logically, the highest concentrations are suspected to be present in the source areas. Evidence supports the potential for near surface transport pathways such as an active stormflow zone transport system with a much smaller contaminant transport component associated with groundwater flow in the perennially saturated zone. Surface contaminants and overflow from trenches may move with the water in the stormflow zone. Based on the available data, hydraulic conductivity tends to decline with depth. Consequently, flow velocities have not been evaluated, but are expected to be lower in the vadose zone than in the overlying stormflow zone. The most significant effect of the storm flow zone in contaminant transport is thought to be the recharge to waste disposal trenches, which intercepts flow in the stormflow and vadose zones.

The Phase 1, Activity 1 sampling effort results indicated potential contaminant migration beyond the northeast boundary of SWSA 6 (SWMU 6.1). Also, there is evidence of contaminant migration and discharge to site streams in three areas. Two areas are located west of the French drain, and one area is located immediately south of the HHMS 7-C Well. All disposal trench areas within WAG 6 are suspect as contributing to contaminant migration into the groundwater. No single disposal area was identified as being the major contributor.

The initial surface water sampling obtained from standing water in the EWB (SWMU 6.2) indicated the presence of tritium above human health criteria. Tritium was also detected in the drainage that transports the discharge from the EWB. Additional data are required in this area during the second Phase 1 sampling

activity to specify whether contaminants are within the EWB or if they originate in the area associated with TARA I.

The area of the EDT (SWMU 6.3) has been filled and capped as a part of the RCRA interim corrective actions undertaken in SWSA 6. Its close proximity to a trench disposal area dictates that it will be an integral part of any corrective actions. Soils collected in the vicinity of the trench indicate that no materials have migrated from the location.

9.2 PRELIMINARY RECOMMENDATIONS FOR Phase 1, Activity 2

The baseline human health evaluation and the fate and transport analysis are being finalized; the following recommendations are based on current data. Final acquisition needs will be assessed shortly after the completion of the site characterization.

Several data elements are required to complete the RFI of WAG 6. Installation of four deep (up to 150 ft) monitoring wells is planned to identify the extent of flow in deeper portions of the shallow aquifer and the potential for vertical migration into the deeper zones and consequently off-site flow of contaminants. The monitoring of wells will also assist in performance assessment.

Delineation of the nature and extent of the contaminant plume exiting the northeast section of the site will be undertaken to provide support in siting groundwater quality assessment monitoring wells. These assessment wells are needed to evaluate the vertical and horizontal extent and rate of contaminant migration.

Groundwater samples will be collected from wells installed during both Phases of field activities. During well installation, soil samples will be collected and analyzed for TCL, organics and inorganics, and radiological constituents with

select samples being analyzed for Appendix IX constituents. Groundwater sampling will be done during high and low water table conditions. All samples will be analyzed for TCL and radiological constituents. Samples from appropriate locations will be analyzed for Appendix IX constituents.

Additional information on flow and contaminant concentrations in surface water are required to aid model calibration for WAG 6. To obtain this information, installation of five flumes with flow-dependent sampling devices is planned. The goal is to obtain a minimum of two storm events--a low-intensity, long-duration storm and a high-intensity short-duration storm. Data will be obtained from all sub-basins in WAG 6. During the Phase 1, Activity investigation, if contaminants are found to be present in the EWB, installation of streamflow measuring devices below the confluence of drainages A and B above the confluence of the west seep may be practical. All samples will be analyzed for TCL and radiological constituents with 10 percent of the samples being analyzed for Appendix IX constituents.

Sediment samples will be collected from the EWB and selected drainages within WAG 6 and analyzed for TCL and radiological constituents with a portion being analyzed for Appendix IX constituents.

Further evaluation of the distribution of the pasteurilla-like bacteria (identified during the preliminary microbiological investigation) is required to determine its distribution in the environment. Development of a plan is underway to determine if the organism is unique to WAG 6 and, if so, the impact to public health. This plan is presently scheduled to be submitted to Energy Systems in early 1990.

The additional field activities discussed in this section will begin in December 1989 and are scheduled for completion by June 1990. The final RFI report for WAG 6 is scheduled to be submitted to Energy Systems in August of 1990.

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